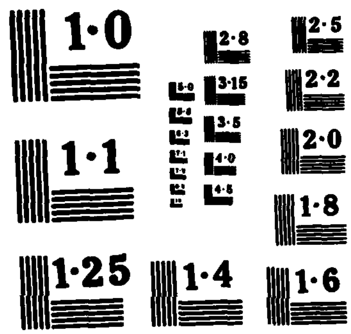
AD-A157 283 FARGO-MOORHEAD URBAN STUDY WATER SUPPLY APPENDIX VOLUME 1/5
1 PHASE 1 PART 1..(U) CORPS OF ENGINEERS ST PAUL MN ST
PAUL DISTRICT MAY 85

UNCLASSIFIED F/G 13/2 NL


1·0
2·8
2·5
3·15
2·2
3·5
2·0
1·1
4·0
1·8
1·25
1·4
1·6

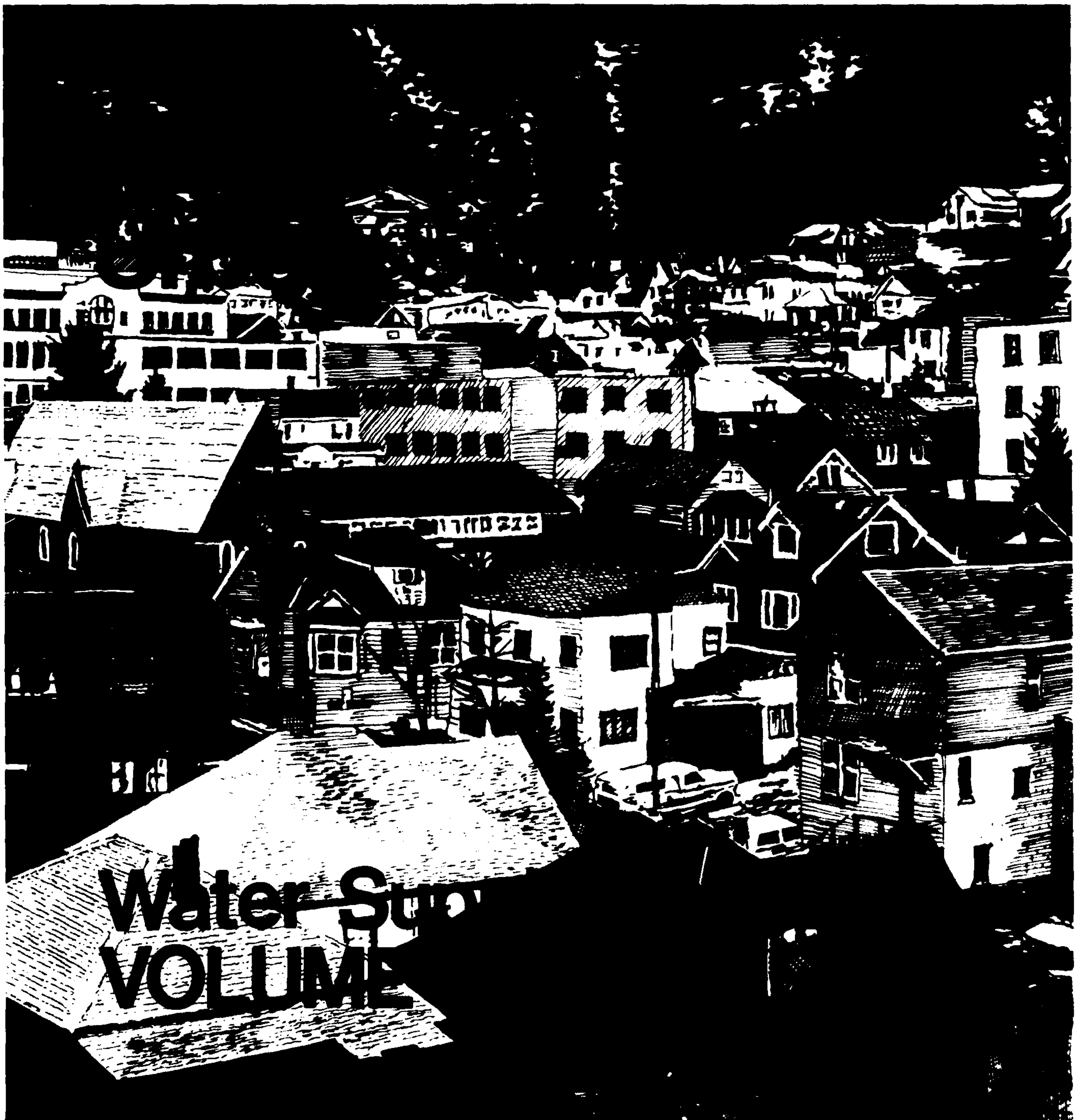
AD-A157 283

DTIC FILE COPY

US Army Corps
of Engineers
St. Paul District

May 1985

(2)



85 7 ... 28

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A157283	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FARGO-MOORHEAD URBAN STUDY; Water Supply Appendix, volume 1. Phase 1, Part 1: Water Demand Projections. Phase 1, Part 2: Low-flow Analyses		5. TYPE OF REPORT & PERIOD COVERED FINAL, ~~1980-2030~~
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St Paul 1135 USPO & Custom House St Paul, MN 55101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE May 1985
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Issued in several parts: Summary Report; Background Information Appendix; Water Supply Appendix (3 volumes); Water Conservation Appendix; Energy Conservation Appendix; Flood Control Appendix; Water Resources Data Management System: a users manual.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

URBAN PLANNING
FARGO (NORTH DAKOTA)
MOORHEAD (MINNESOTA)
WATER TREATMENT

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Fargo-Moorhead Urban Study is a cooperative Federal, State and local planning effort aimed at developing viable solutions to water and related land resource problems, needs and concerns for 1980-2030.

The summary report contains a brief, non-technical overview. Readers desiring additonal detailed information should review the appropriate technical appendixes.

The objective of this report was to develop water demand projections for

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

the Fargo-Moorhead area for the planning period 1980-2030. Projected water demands will be compared with flows of selected study area rivers to determine whether surface water supplies can meet future demands.

Phase 1 examines surface water supply for the Red River of the North, Sheyenne River, Maple River, Buffalo River, and South Branch Buffalo River.

FARGO-MOORHEAD URBAN STUDY

WATER SUPPLY APPENDIX

VOLUME I

PHASE 1, PART 1
WATER DEMAND PROJECTIONS

PHASE 1, PART 2
LOW-FLOW ANALYSES

St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479

MAY 1985

PREFACE

The Fargo-Moorhead Urban Study was sponsored by the St. Paul District, Corps of Engineers, as a cooperative effort of local, State, and Federal agencies. The results of this study are contained within the following documents:

- Summary Report
- Background Information Appendix
- Water Supply Appendix (3 Volumes)
- Water Conservation Appendix
- Energy Conservation Appendix
- Flood Control Appendix
- Fargo-Moorhead Water Resource Data Management System Appendix (3 Volumes)

The Summary Report contains a brief, non-technical overview of the results of the overall study. Only readers desiring additional detailed information should review the appropriate technical appendixes.

FARGO-MOORHEAD URBAN STUDY

WATER SUPPLY

PHASE 1, PART 1

WATER DEMAND PROJECTIONS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

i

SUMMARY

The objective of this study was to develop water demand projections for the Fargo-Moorhead area for the planning period of 1980-2030. Projected water demands will be compared with flows of selected study area rivers to determine whether surface water supplies can meet future demands.

Information on water supply sources, wastewater systems, and past and present water withdrawals and discharges was obtained from State agencies, representatives of communities, and major water users in the study area. Projected water demands and return flows for municipal, self-served industrial, irrigation, and livestock water uses in the area were developed on the basis of withdrawal and discharge records, population projections, and other pertinent information.

Water demand projections through 2030 were also developed in 1976-77 for the Grand Forks-East Grand Forks Urban Study's water supply investigation. The previous and present demand projections are in general agreement with the exception of a significant decline in the projected 2030 Fargo municipal demand. The decline is attributed mostly to the difference in Fargo population projections.

STUDY OBJECTIVES

The St. Paul District, U.S. Army Corps of Engineers, is undertaking a three-phased water resource study for the Fargo-Moorhead area in Minnesota and North Dakota (figure 1). The objective of Phase 1 is to determine whether surface waters in the area can meet the area's demands and, if not, the amount of demand reduction or additional supply required. More specifically, selected study area rivers -- the Red River of the North, Sheyenne River, Maple River, Buffalo River, and South Branch Buffalo River -- will be examined to determine if flows will meet projected water demands during a severe drought in the 1980-2030 planning period. Phase 2 involves the evaluation of alternative water sources and water treatment and distribution systems. Water conservation and drought contingency measures will be examined in Phase 3.

The first part of Phase 1 involves identifying present (1980) and projecting future water demands for the particular years of interest -- 2030, 2000, and 1990. During the second part of Phase 1, the study area rivers' water supply capabilities will be compared to the projected demands to determine if (or possibly when) the demand exceeds surface water supply. Water demand projections for these years were developed in 1976-77 as part of the Grand Forks-East Grand Forks Urban Water Resources Study. However, the Fargo-Moorhead projections previously compiled are not directly suitable for use in this study because some of the smaller communities in the area were disregarded and others were represented by cumulative demands. Furthermore, possible changes in residential, commercial, industrial, and irrigation water uses or the development of new trends since the 1976-77 compilation warrant a reassessment of the projections.

The objective of this report is to present the water demands developed for the Fargo-Moorhead area for the 1980-2030 period, reflecting the current growth pattern and potential of area communities.

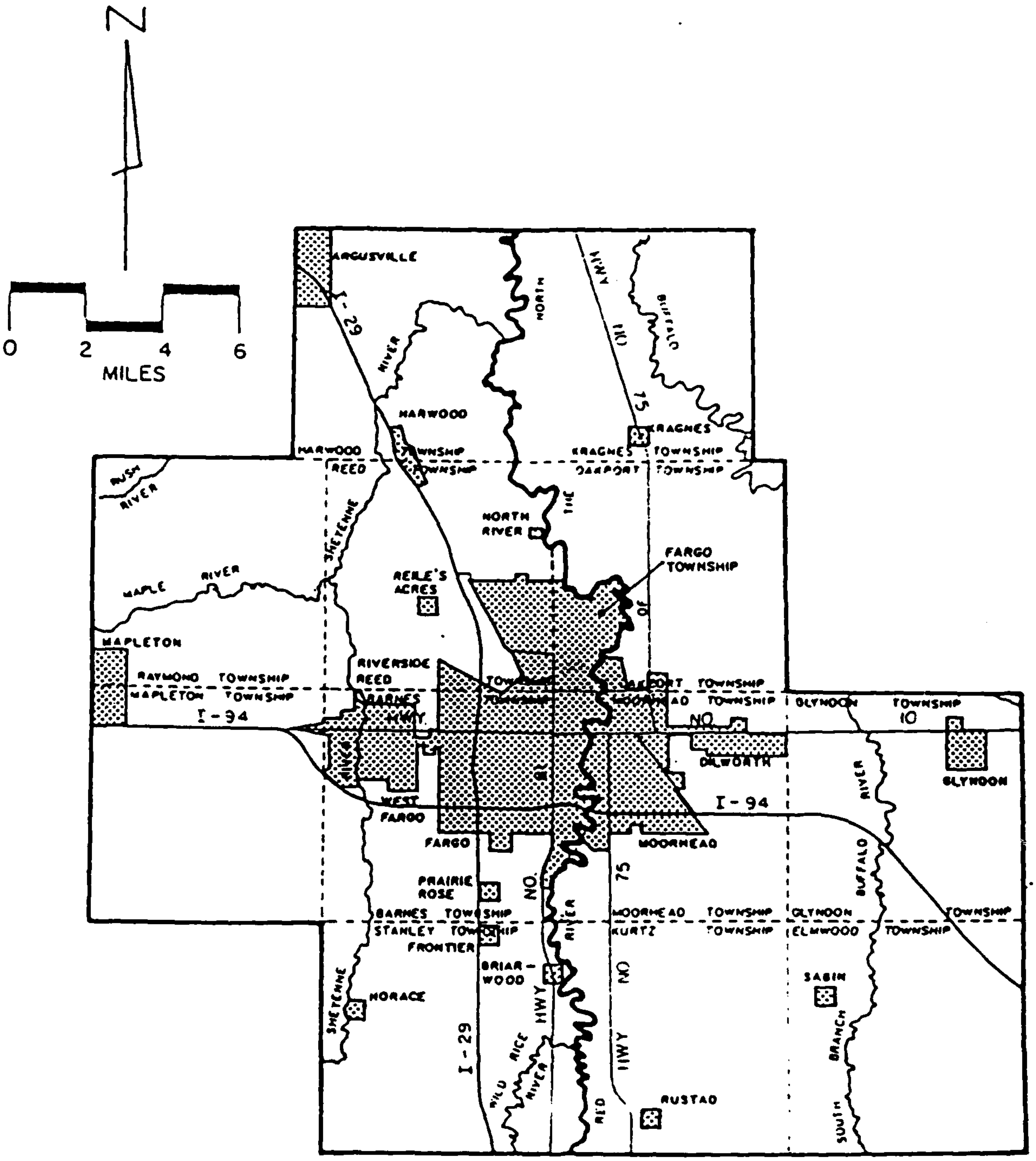


FIGURE 1
Fargo-Moorhead Study Area

PROCEDURES

INFORMATION ACQUISITION

A survey of water use in the study area constituted the first step of the investigation. Water withdrawal and discharge permit information was obtained from the North Dakota State Water Commission and Department of Health and the Minnesota Department of Natural Resources and Pollution Control Agency. Information on water supply sources, wastewater systems, and water withdrawals and discharges was obtained from representatives of communities and other major water users (predominantly industries). Available information varied from complete monthly withdrawal and discharge records for 1969-1981 (e.g., Fargo and Moorhead municipal systems) to general descriptions of water supply and wastewater systems. General information on water supply and wastewater systems for communities is summarized in table 1.

The St. Paul District, Corps of Engineers, provided pertinent publications (Minnesota Department of Health, 1981; Souris-Red-Rainy River Basins Commission, 1972; U.S. Army Corps of Engineers, February 1981; and U.S. Army Corps of Engineers, July 1981) and the backup data for the demand projections developed in 1976-77 for the Grand Forks-East Grand Forks Urban Study. Population projections for the study area communities through the year 2030 were obtained from the Corps of Engineers and the Fargo-Moorhead Metropolitan Council of Governments.

GENERAL METHODS AND ASSUMPTIONS

Because of the variety of water uses, water supply and wastewater systems, and types of available information in the study area, assumptions and professional judgments were necessary in the development of water demand and return flow projections. The general assumptions and methods used to determine projected demands and return flows are discussed in this section. More specific information and assumptions pertaining to the projections for individual water users is provided in Appendix I.

TABLE 1

Summary of Water Supply Sources and Wastewater Facilities
for Fargo-Moorhead Area Communities

Community	Water Supply Source	Wastewater Facility
Argusville, ND	CRWUA[1]	Lagoon discharging to Red River via drainage ditch.
Briarwood, ND	CRWUA	Individual septic systems.
Dilworth, MN	Three city wells in Kragnes aquifer.	Moorhead municipal system.
Fargo, ND	Red River	Lagoon discharging to Red River.
Frontier, ND	CRWUA	Individual septic systems.
Glyndon, MN	Two city wells in Buffalo aquifer.	Lagoon discharging to Buffalo River.
Harwood, ND	Two city wells in undesignated aquifer.	Lagoon discharging to Red River via drainage ditch.
Horace, ND	Five city wells in undesignated aquifer.	Lagoon discharging to Red River via drainage ditch.
Kragnes, MN	Individual wells in undesignated aquifer.	Individual septic systems.
Mapleton, ND	CRWUA	Lagoon discharging to Maple River (no discharges in 5 years).
Moorhead, MN	Red River, two city wells in Moorhead aquifer and three city wells in Buffalo aquifer.	Wastewater treatment plant discharging to Red River.
North River, ND	CRWUA	Individual septic systems.
Prairie Rose, ND	Individual wells in undesignated aquifer.	Individual septic systems.
Reile's Acres, ND	Wells in undesignated aquifer, each serving a few homes. CRWUA supplies four or five homes.	Individual septic systems.

(1)CRWUA denotes Cass Rural Water Users Association.

TABLE 1 (continued)

Community	Water Supply Source	Wastewater Facility
Riverside, ND	One city well in West Fargo aquifer.	Treatment plant discharging to Sheyenne River or to holding pond which discharges to Sheyenne River.
Rustad, MN	Individual wells in undesignated aquifer.	Individual septic systems.
Sabin, MN	One city well in Buffalo aquifer.	Lagoon discharging to Red River via drainage ditch.
West Fargo, ND	Four city wells in West Fargo aquifer.	Lagoon discharging to Sheyenne River.
CRWUA(1)	Three wells located 4 miles southeast of Horace in the West Fargo aquifer serve Briarwood, Frontier, Mapleton, North River, and Reile's Acres. Argusville is served by a CRWUA well in the Page aquifer located in western Cass County.	

(1)CRWUA denotes Cass Rural Water Users Association.

Municipalities

Projected municipal water demands were based on population projections provided by the Corps of Engineers and the Fargo-Moorhead Metropolitan Council of Governments (table 2). Minor modifications were made where community representatives provided different 1980 figures reflecting the populations served by the water supply systems. In these cases, populations were projected to increase by the same percentage each decade as anticipated in the original projections.

Municipal withdrawal records generally indicate an increase in per capita water use over the past decade. However, improving water conservation methods and more efficient water use may offset this trend. Per capita water use was greatest during 1980, possibly resulting from abnormally low precipitation. Available records show per capita water use declined from 1980 to 1981; however, future per capita use was assumed to not change significantly from the 1980 values. This assumption effectively blends an increase in future per capita use (as compared to average recent use) and effects of future conservation efforts. (The single exception to this approach was Riverside, North Dakota, which is predominantly zoned industrial and for which a 10-percent increase in per capita use per decade was assumed.)

Projected annual demands for each community are thus the product of projected population and present (1980) per capita use. This method does not distinguish between residential and commercial or industrial use of municipal water. Rather, this approach assumes that commercial and industrial growth and water use are closely related to population growth and present per capita water use. This approach was also used to determine the municipal demand projections for the Grand Forks-East Grand Forks Urban Study's water supply investigation.

TABLE 2

Population Projections Used in Water Demand Projections for Fargo-Moorhead Area Communities(1)

Community	Year 1980	1990	2000	2010	2020	2030
North Dakota						
Argusville	147	147	147	147	147	147
Briarwood	57	80	80	80	80	80
Fargo	61,281	66,700	71,388	81,000	90,500	99,500
Frontier	152	163	174	185	196	207
Harwood(2)	540	590	677	767	855	944
Horace	497	556	601	740	900	1,000
Mapleton	307	327	350	450	600	700
North River	65	85	110	145	190	250
Prairie Rose(2)	76	91	106	136	182	228
Reile's Acres	191	191	191	191	191	191
Riverside	465	600	600	600	600	600
West Fargo	10,080	13,000	15,500	17,800	20,200	23,500
Minnesota						
Dilworth(3)	2,578	2,863	3,180	3,533	3,924	4,358
Glyndon	882	982	1,007	1,032	1,058	1,084
Kragnes	30	30	30	30	30	30
Moorhead(3)	29,925	33,000	38,000	41,000	43,000	45,000
Rustad	44	45	46	47	48	50
Sabin(2)	630	807	949	1,092	1,234	1,376

(1) Population figures provided by Corps of Engineers unless otherwise noted.

(2) Corps of Engineers population projections were modified to incorporate 1980 population served by water supply system as provided by community representative.

(3) Population projections provided by Fargo-Moorhead Metropolitan Council of Governments.

Monthly municipal demands were projected to occur in the average pattern of withdrawals observed during a recent period (usually 1979-1981). Monthly percentages of annual withdrawals were averaged for the recent period of record and were applied to annual demand projections to determine monthly demand projections.

Annual return flows from municipal wastewater systems were projected to be proportional to the projected demands. The average ratio of return flow to withdrawal for a particular municipal system was determined from recent years of discharge records, if available. The average percentage return of withdrawal as determined from recent records was assumed to remain constant through the year 2030 and was applied to projected annual demands to obtain projected annual return flows. Projected monthly return flows were based on monthly discharge records for recent years and were assigned in a manner analogous to the assignment of projected monthly demands.

As an example of the calculation procedure used to determine projected municipal demands and return flows, the analysis for the Fargo municipal system is provided in Appendix II.

Self-Served Industry

Self-served major water using industries were considered individually. Water demand and return flow projections were based on existing records, where available, with monthly projections assigned in a procedure analogous to that used for municipal projections. Representatives of several industries were contacted in regard to future changes in production which may affect water use. In most cases, no significant changes in water use were presently foreseen; thus, projected demands and return flows were assumed constant.

Irrigation and Livestock

Irrigation water demands were based on permit information. The demand for a given river reach was assumed to include permitted surface water withdrawals and groundwater withdrawals adjacent to the stream. Present and projected demands are assumed to be 50 percent of the permit allotment. This value is considered representative of average long-term irrigation water use. Actual water use during any particular year is expected to vary. Irrigation demands are assumed constant for the projected period because of the presently restricted availability of surface water for irrigation use and irrigable land adjacent to streams. Monthly irrigation withdrawals were assumed to occur during the 5-month period of May through September in the same pattern determined in the 1976-77 demand projections for the Grand Forks-East Grand Forks Urban Study.

Irrigation return flows are projected to be 20 percent of projected withdrawals. The return flow is assumed to return to the stream from which the water was withdrawn through shallow groundwater flow or surface runoff.

Livestock water demands were assumed to be 1.1 million gallons per year per river mile, as was previously determined for the Grand Forks-East Grand Forks Urban Study. This figure was used to assign demands to river reaches in the study area. Projected demands are assumed constant.

RESULTS

Present and projected water demands and return flows for municipal, self-served industrial, irrigation, and livestock water uses for the years of interest -- 2030, 2000, 1990, and 1980 -- are listed in table 3. The pattern of 1980 monthly demands and return flows differs from those projected in several cases because the 1980 information represents actual withdrawals and discharges while projections are based on average withdrawal and discharge patterns observed during recent years. Only independent withdrawals and discharges are listed for self-served industries (i.e., if additional municipal water is used, it is included in municipal demands).

The demand projections presented here were developed in a similar fashion to the projections used for the Grand Forks-East Grand Forks Urban Study's water supply investigation. The present demand projections are generally comparable to those estimated in the 1976-77 work with the exception of the 2030 Fargo municipal demand. The average projected 2030 municipal demands for Fargo in the present and 1976-77 investigations are 26.0 cubic feet per second (cfs) and 37.1 cfs, respectively. The change in demand projections is attributed mostly to the difference in population projections. The projected 2030 Fargo populations used in the present and previous investigations were 99,500 and 123,135.

TABLE 3

Fargo-Moorhead Area Water Demand and Return Flow Information

Water User	Source or Receiving Body	Year	Month											
			J	F	M	A	M	J	J	A	S	O	N	D
			Demand (cfs)											
Fargo, ND	Red River	1980	12.18	13.70	12.67	16.75	23.25	16.56	24.84	17.40	14.42	13.34	13.59	13.05
		1990	14.36	18.17	16.41	16.95	20.51	19.07	22.56	18.46	16.95	16.41	14.84	14.36
		2000	15.37	19.45	17.56	18.14	21.95	20.41	24.15	19.76	18.14	17.56	15.88	15.37
		2030	21.42	27.11	24.48	25.29	30.60	28.45	33.65	27.54	25.29	24.48	22.14	21.42
			Return Flow (cfs)											
	Red River	1980	0	0	0	0	30.59	16.60	0	15.32	19.46	0	25.06	9.43
		1990	0	0	0	9.54	27.69	20.66	12.31	15.38	12.72	15.38	30.20	12.31
		2000	0	0	0	10.21	29.64	22.11	13.18	16.46	13.61	16.46	32.32	13.18
		2030	0	0	0	14.23	41.31	30.82	18.36	22.94	18.98	22.94	45.05	18.36
			Demand (cfs)											
West Fargo, ND	West Fargo aquifer	1980	1.07	1.28	1.16	1.53	2.30	1.46	2.16	1.58	1.21	1.18	1.13	1.20
		1990	1.22	1.57	1.62	1.89	2.23	1.89	2.03	1.83	1.68	1.62	1.68	1.42
		2000	1.45	1.87	1.93	2.25	2.66	2.25	2.42	2.18	2.00	1.93	2.00	1.69
		2030	2.21	2.84	2.93	3.42	4.03	3.42	3.67	3.31	3.04	2.93	3.04	2.57

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Return Flow (cfs)											
West Fargo, ND (continued)	Sheyenne River	1980	0	0	0	0	3.25	1.52	0	0	2.65	0	1.52	0
		1990	0	0	0	1.01	1.79	2.52	2.44	1.14	2.52	1.62	1.68	1.79
		2000	0	0	0	1.20	2.13	3.00	2.91	1.36	3.00	1.93	2.00	2.13
		2030	0	0	0	1.83	3.24	4.56	4.41	2.06	4.56	2.93	3.04	3.24
			Demand (cfs)											
Riverside, ND(1)	West Fargo aquifer	1980	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
		1990	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
		2000	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
		2030	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
			Return Flow (cfs)											
	Sheyenne River	1980	0	0	0	0	0	0	0	0	0	0	0	0
		1990	0	0	0	0.09	0	0.09	0	0.09	0	0.09	0	0
		2000	0	0	0	0.10	0	0.10	0	0.10	0	0.10	0	0
		2030	0	0	0	0.12	0	0.12	0	0.12	0	0.12	0	0

(1)Riverside may connect to West Fargo sewer system in future.

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Demand (cfs)											
Harwood, ND	Undesignated aquifer	1980	0.05	0.05	0.04	0.06	0.14	0.06	0.11	0.08	0.05	0.05	0.05	0.05
		1990	0.06	0.06	0.05	0.07	0.11	0.07	0.10	0.08	0.07	0.07	0.06	0.06
		2000	0.07	0.06	0.06	0.08	0.12	0.08	0.12	0.10	0.08	0.08	0.07	0.07
		2030	0.09	0.09	0.08	0.11	0.18	0.11	0.16	0.14	0.11	0.11	0.10	0.10
			Return Flow (cfs)											
	Red River	1980	0	0	0	0	0	0	0	0	0	0	0	0
		1990	0	0	0.19	0	0	0	0	0	0	0.19	0	0
		2000	0	0	0.21	0	0	0	0	0	0	0.21	0	0
		2030	0	0	0.30	0	0	0	0	0	0	0.30	0	0
			Demand (cfs)											
Horace, ND	Undesignated aquifer	1980	0.03	0.04	0.04	0.05	0.05	0.05	0.07	0.05	0.04	0.05	0.04	0.03
		1990	0.04	0.05	0.04	0.05	0.05	0.06	0.08	0.06	0.05	0.05	0.05	0.03
		2000	0.04	0.05	0.04	0.06	0.06	0.06	0.08	0.06	0.06	0.06	0.05	0.04
		2030	0.07	0.08	0.07	0.09	0.10	0.11	0.14	0.10	0.09	0.10	0.09	0.06

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Return Flow (cfs)											
Horace, ND (continued)	Red River	1980	0	0	0	0.05	0	0	0	0	0	0	0.05	0
		1990	0	0	0	0.06	0	0	0	0	0	0	0.06	0
		2000	0	0	0	0.07	0	0	0	0	0	0	0.07	0
		2030	0	0	0	0.11	0	0	0	0	0	0	0.11	0
			Demand (cfs)											
Prairie Rose, ND	Undesignated aquifer	1980-2000	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		2030	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
			Return Flow (cfs)											
			Individual septic systems used. Return flows considered negligible.											
			Demand (cfs)											
Reile's Acres, ND	Undesignated aquifer, CRWUA(1)	1980-2030	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
			Return Flow (cfs)											
			Individual septic systems used. Return flow considered negligible.											

(1)Reile's Acres typically has one well serving a few homes. Four or five homes receive water from the Cass Rural Water Users Association.

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Demand (cfs)											
CRWUA, Kindred, ND	West Fargo aquifer(1)	1980	0.53	0.54	0.41	0.60	0.85	0.70	0.74	0.68	0.72	0.66	0.69	0.67
		1990	0.59	0.56	0.50	0.69	0.76	0.78	0.84	0.76	0.78	0.76	0.78	0.76
		2000	0.63	0.60	0.53	0.74	0.81	0.83	0.90	0.81	0.83	0.81	0.83	0.81
		2030	1.00	0.95	0.84	1.16	1.28	1.32	1.42	1.28	1.32	1.28	1.32	1.28
			Demand (cfs)											
Mapleton, ND	CRWUA	1980	0.02	0.02	0.02	0.03	0.02	0.05	0.03	0.03	0.03	0.03	0.03	0.03
		1990	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.03
		2000	0.03	0.03	0.03	0.03	0.03	0.05	0.04	0.04	0.04	0.03	0.03	0.03
		2030	0.06	0.05	0.06	0.06	0.06	0.09	0.09	0.08	0.08	0.06	0.07	0.05
			Return Flow (cfs)											
	Maple River	1980–2000	0	0	0	0	0	0	0	0	0	0	0	0
		2030	0	0	0	0	0.08	0	0	0	0.08	0	0	0
			Demand (cfs)											
Briarwood, ND	CRWUA	1980–2030	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
			Return Flow (cfs)											
			Individual septic systems used. Return flow considered negligible.											

(1)CRWUA well field is located about 4 miles southeast of Horace, North Dakota (N1/2 Sec. 3, T137N, R49W).

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Demand (cfs)											
Argusville, ND	CRWUA	1980–2030	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
			Return Flow (cfs)											
	Red River	1980–2030	0	0	0	0.09	0	0	0	0	0	0	0	0
			Demand (cfs)											
Frontier, ND	CRWUA	1980–2030	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
			Return Flow (cfs)											
			Individual septic systems used. Return flow considered negligible.											
			Demand (cfs)											
North River, ND	CRWUA	1980–2000	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		2030	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
			Return Flow (cfs)											
		1980–2030	Individual septic systems used. Return flow considered negligible.											

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Month											
			Demand (cfs)(1)											
Moorhead, MN	Red River	1980	3.12	3.31	3.16	2.64	5.01	3.76	5.11	3.61	3.25	3.79	3.54	3.38
	Moorhead aquifer		0.70	0.74	0.85	1.29	1.06	0.74	1.25	0.84	0.83	0.46	0.39	0.63
	Buffalo aquifer		1.70	1.86	1.82	3.10	3.12	2.01	3.11	2.02	2.08	1.75	1.76	1.87
	Total		5.52	5.91	5.83	7.03	9.19	6.51	9.47	6.47	6.16	6.00	5.69	5.88
	Red River	1990	3.87	4.28	3.38	3.50	4.35	4.49	4.83	4.35	4.49	3.87	4.00	3.87
	Moorhead aquifer		1.01	0.75	1.01	0.70	1.01	0.81	1.23	1.12	0.93	1.01	0.93	0.90
	Buffalo aquifer		1.87	2.07	2.68	2.76	2.68	2.21	2.41	2.14	2.21	2.41	1.94	1.87
	Total		6.75	7.10	7.07	6.96	8.04	7.51	8.47	7.61	7.63	7.29	6.87	6.64
	Red River	2000	4.46	4.93	3.89	4.03	5.01	5.17	5.56	5.01	5.17	4.46	4.61	4.46
	Moorhead aquifer		1.16	0.86	1.16	0.81	1.16	0.93	1.42	1.29	1.07	1.16	1.07	1.04
	Buffalo aquifer		2.15	2.38	3.09	3.18	3.09	2.54	2.78	2.46	2.54	2.78	2.23	2.15
	Total		7.77	8.17	8.14	8.02	9.26	8.64	9.76	8.76	8.78	8.40	7.91	7.65
	Red River	2030	5.28	5.84	4.61	4.77	5.93	6.12	6.59	5.93	6.12	5.28	5.45	5.28
	Moorhead aquifer		1.38	1.02	1.38	0.95	1.38	1.10	1.68	1.53	1.27	1.38	1.27	1.23
	Buffalo aquifer		2.55	2.82	3.65	3.76	3.65	3.01	3.29	2.92	3.01	3.29	2.65	2.55
	Total		9.21	9.68	9.64	9.48	10.96	10.23	11.56	10.38	10.40	9.95	9.37	9.06

(1)Moorhead demand projections assume recent (1979–1981) pattern of withdrawal from the three sources.

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	Month J	F	M	A	M	J	J	A	S	O	N	D
			Return Flow (cfs)[1]											
Moorhead, MN (continued)	Red River	1980	5.51	5.52	5.93	6.06	5.71	5.94	5.63	5.68	6.41	5.93	5.65	5.99
		1990	6.06	5.87	6.06	7.83	6.82	7.05	6.06	6.06	6.27	6.82	6.27	6.06
		2000	6.96	6.74	6.96	8.99	7.83	8.10	6.96	6.96	7.20	7.83	7.20	6.96
		2030	8.34	8.08	8.34	10.78	9.39	9.70	8.34	8.34	8.63	9.39	8.63	8.34
			Demand (cfs)											
Dilworth, MN	Kragnes aquifer	1980	0.16	0.25	0.20	0.34	0.50	0.35	0.48	0.37	0.29	0.29	0.30	0.29
		1990	0.25	0.32	0.33	0.35	0.42	0.43	0.42	0.42	0.35	0.29	0.34	0.34
		2000	0.28	0.36	0.37	0.38	0.47	0.48	0.47	0.46	0.38	0.33	0.38	0.37
		2030	0.38	0.49	0.51	0.52	0.63	0.66	0.64	0.64	0.53	0.44	0.52	0.51
			Return Flow (cfs)											
		1980–2030	Dilworth wastewater discharged to Moorhead sewer system.											

(1)Moorhead return flows include return flows from Dilworth, Minnesota.

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Month											
			Demand (cfs)											
Glyndon, MN	Buffalo aquifer	1980	0.11	0.12	0.11	0.15	0.25	0.18	0.23	0.16	0.13	0.13	0.10	0.11
		1990	0.14	0.15	0.14	0.16	0.23	0.20	0.19	0.18	0.16	0.15	0.14	0.14
		2000	0.14	0.15	0.14	0.16	0.24	0.21	0.20	0.18	0.16	0.16	0.15	0.14
		2030	0.15	0.17	0.15	0.18	0.26	0.22	0.21	0.19	0.18	0.17	0.16	0.15
			Return Flow (cfs)											
	Buffalo River	1980	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
		1990	0.11	0.11	0.11'	0.113	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
		2000	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
		2030	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
			Demand (cfs)											
Sabin, MN	Buffalo aquifer	1980	0.07	0.08	0.08	0.09	0.12	0.11	0.10	0.09	0.08	0.08	0.08	0.07
		1990	0.09	0.10	0.09	0.11	0.16	0.14	0.13	0.12	0.11	0.11	0.10	0.09
		2000	0.10	0.12	0.11	0.13	0.19	0.16	0.16	0.14	0.13	0.12	0.11	0.11
		2030	0.16	0.17	0.16	0.19	0.27	0.23	0.23	0.20	0.19	0.18	0.16	0.16

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	Month J	F	M	A	M	J	J	A	S	O	N	D
			Return Flow (cfs)											
Sabin, MN (continued)	Red River	1980	0	0	0	0	0	0.36	0	0	0	0.36	0	0
		1990	0	0	0	0	0	0.46	0	0	0	0.46	0	0
		2000	0	0	0	0	0	0.55	0	0	0	0.55	0	0
		2030	0	0	0	0	0	0.79	0	0	0	0.79	0	0
			Demand (cfs)											
Rustad, MN	Undesignated aquifer	1980–2030	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
			Return Flow (cfs)											
			Individual septic systems used. Return flow considered negligible.											
Kragnes, MN		1980–2030	Individual wells and septic systems used. Demand and return flow considered negligible.											

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Month											
			Demand (cfs)											
American Crystal Sugar(1), Moorhead, MN	Red River	1980	0	0	0	0	0	0	0	0	0	0	0	0
		1990-2030	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
			Return Flow (cfs)											
	Red River	1980	0	0	0	0	0	0.19	0.99	0.09	0	0	0	0
		1990-2030	0	0	0	0	0	0	0	0	0	0	0	0
			Demand (cfs)											
Moorhead Power Plant	Red River	1980	0.79	0.79	0	0	0	0	0.79	0.79	0	0	0	0
		1990-2030	1.02	1.02	0	0	0	0	1.02	1.02	0	0	0	0
			Return Flow (cfs)											
			Water used for evaporative cooling. No return flow expected.											

(1)Projected American Crystal Sugar withdrawals represent makeup to water recycling system. Negligible projected return flow is expected because the company recycles water. Additional production water is obtained from and discharged to Moorhead municipal systems.

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Demand (cfs)											
Cargill Sunflower Plant[1], Riverside, ND	West Fargo aquifer	1990–2030	0.26	0.28	0.25	0.21	0.14	0.17	0.21	0.09	0.08	0.13	0.21	0.22
			Demand (cfs)											
Held Beef Industries[2], West Fargo, ND	West Fargo aquifer	1980–2030	0.75	0.74	0.64	0.61	0.52	0.73	0.70	0.78	0.66	0.73	0.94	0.66
			Demand (cfs)											
Cass-Clay Creamery[3], Fargo, ND	Fargo aquifer	1980–2030	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
			Demand (cfs)											
Union Stockyards[4], West Fargo, ND	West Fargo aquifer	1980	0.20	0.17	0.16	0.15	0.26	0.15	0.10	0.08	0.07	0.06	0.06	0.07
		1990–2030	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05
			Return Flow (cfs)											
	Sheyenne River	1980	0.22	0.18	0.20	0.22	0.22	0.22	0.12	0.12	0.12	0.07	0.07	0.07
		1990–2030	0.06	0.06	0.06	0.10	0.10	0.10	0.10	0.10	0.10	0.07	0.07	0.07

(1)Cargill began pumping from its own well in October 1980. Additional water is received from Riverside. Return flow is discharged to Riverside municipal system.
(2)Held Beef return flow is discharged to West Fargo municipal system.
(3)Cass-Clay Creamery receives additional water from Fargo. Return flow is discharged to Fargo municipal system.
(4)Future demand and return flow may be less than projected as a result of water conservation efforts.

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Month											
			Demand (cfs)											
Irrigation(1)	Maple River from Mapleton to Sheyenne River	1980–2030	0	0	0	0	0.18	0.37	1.86	1.36	0.80	0	0	0
			Return Flow (cfs)											
			0	0	0	0	0.04	0.07	0.37	0.27	0.16	0	0	0
Irrigation(1)	Sheyenne River:													
			Demand (cfs)											
	– West Fargo to Maple River	1980–2030	0	0	0	0	0.01	0.02	0.07	0.05	0.03	0	0	0
			Return Flow (cfs)											
			0	0	0	0	0	0	0.01	0.01	0.01	0	0	0
			Demand (cfs)											
	– Maple River to Harwood	1980–2030	0	0	0	0	0.04	0.08	0.36	0.26	0.17	0	0	0
			Return Flow (cfs)											
			0	0	0	0	0.01	0.02	0.07	0.05	0.03	0	0	0
			Demand (cfs)											
	– Harwood to Red River	1980–2030	0	0	0	0	0.02	0.05	0.20	0.15	0.10	0	0	0
			Return Flow (cfs)											
			0	0	0	0	0	0.01	0.04	0.03	0.02	0	0	0

(1)Demand is estimated to be 50 percent of permit allotment. Return flow is estimated to be 20 percent of demand.

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Month											
			Demand (cfs)											
Irrigation(1)	South Branch Buffalo from Sabin to Buffalo River(2)	1980–2030	0	0	0	0	0.51	1.18	5.26	3.85	2.51	0	0	0
			Return Flow (cfs)											
			0	0	0	0	0.10	0.24	1.05	0.77	0.50	0	0	0
Irrigation(1)	Buffalo River:													
			Demand (cfs)											
	- South Branch Buffalo to Kragnes(3)	1980–2030	0	0	0	0	0.05	0.12	0.52	0.38	0.25	0	0	0
			Return Flow (cfs)											
			0	0	0	0	0.01	0.02	0.10	0.08	0.05	0	0	0
			Demand (cfs)											
	- Kragnes to Red River	1980–2030	0	0	0	0	0.04	0.08	0.36	0.26	0.17	0	0	0
			Return Flow (cfs)											
			0	0	0	0	0.01	0.02	0.07	0.05	0.03	0	0	0
			Demand (cfs)											
Irrigation(1)	Red River from Briarwood to Fargo	1980–2030	0	0	0	0	0.25	0.57	2.53	1.85	1.21	0	0	0
			Return Flow (cfs)											
			0	0	0	0	0.05	0.11	0.51	0.37	0.24	0	0	0

(1)Demand is estimated to be 50 percent of permit allotment. Return flow is estimated to be 20 percent of demand.
(2)Groundwater supplies 74 percent of demand along this reach of the South Branch Buffalo River.
(3)Groundwater supplies 19 percent of demand along this reach of the Buffalo River.

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Demand (cfs)											
Livestock(1)	Maple River from Mapleton to Sheyenne River	1980–2030	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Livestock(1)	Sheyenne River:													
			Demand (cfs)											
	– Horace to West Fargo	1980–2030	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	– West Fargo to Maple River	1980–2030	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	– Maple River to Red River	1980–2030	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
			Demand (cfs)											
Livestock(1)	South Branch Buffalo from Sabin to Buffalo River	1980–2030	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
			Demand (cfs)											
Livestock(1)	Buffalo River from South Branch Buffalo to Red River	1980–2030	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

(1)Livestock demand based on average demand of 1.1 million gallons per year per river mile.
Return flow considered negligible.

TABLE 3 (continued)

Water User	Source or Receiving Body	Year	J	F	M	A	M	J	J	A	S	O	N	D
			Demand (cfs)											
Livestock(1)	Red River:													
	– Rustad to Fargo	1980–2030	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	– Fargo to Sheyenne River	1980–2030	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

(1)Livestock demand based on average demand of 1.1 million gallons per year per river mile. Return flow considered negligible.

APPENDIX I

SPECIFIC INFORMATION AND ASSUMPTIONS PERTAINING TO INDIVIDUAL WATER DEMAND PROJECTIONS

American Crystal Sugar, Moorhead, Minnesota

American Crystal Sugar receives water from Moorhead and also by direct intake from the Red River. Approximately 0.25 million gallons per day (mgd) of municipal water is used in a new process of sugar extraction from molasses. Wastewater from this process is discharged to the Moorhead sewer system. No significant change in future use of municipal water is foreseen.

Water withdrawn from the Red River is used for sugar beet processing. In recent years, wastewater was treated and returned to the Red River from wastewater ponds. Because of return flow quality problems, water recycling is practiced. During the transition, no water was withdrawn from the Red River in 1980. Future withdrawals are expected to be 150 million gallons per year from the Red River for makeup to the recycling system with no discharge.

Argusville, North Dakota

Argusville began total use of Cass Rural Water Users Association water in October 1981. Previously, water was obtained from one municipal well. The 1980 monthly well withdrawals were assumed to represent projected demands because the population is not expected to increase.

Wastewater is discharged from a lagoon to the Red River via a drainage ditch. The lagoon is usually discharged for 3 days each year at an average rate of 0.6 mgd, resulting in an annual discharge of about 1.8 million gallons. The return flow is assumed to remain constant through the year 2030; discharges are assumed to be in April of each year.

Briarwood, North Dakota

Water is supplied to Briarwood by the Cass Rural Water Users Association. In 1980, total water delivery to Briarwood was 1.59 million gallons for 57 people (about 76 gallons per capita per day). Projecting from the 1980 per capita use resulted in a demand of 2.23 million gallons per year for the projected population of 80 during 1990-2030.

Individual septic systems are used for wastewater disposal. Because of the low present and projected water demand (about 0.01 cfs), return flow is assumed to be negligible.

Busch Agricultural Resources, Moorhead, Minnesota

The Anheuser-Busch malt plant receives its water supply from Moorhead. During 1980, the malt plant received 273 million gallons, approximately 18 percent of the total 1980 Moorhead withdrawal. Wastewater is discharged to the Moorhead municipal system. No significant change in future water use is foreseen.

Cargill Sunflower Plant, Riverside, North Dakota

Cargill obtains water from both Riverside and a private well in the West Fargo aquifer. Use of the private well began in October 1980 when processing operations started. Projected demands are assumed equal to 1981 water use (plus an additional 15 percent resulting from an unusual "downtime" in 1981) because no significant change in water use is foreseen. Wastewater is discharged to the Riverside municipal system.

Cass-Clay Creamery, Fargo, North Dakota

The Cass-Clay Creamery obtains water from Fargo and its own well. The well is 191 feet deep; the Fargo aquifer is the probable source. Well withdrawal records were not available. Present and projected water use is assumed equal to the permitted amount of 65.2 million gallons per year because the private well is expected to be a more economical source than municipal water. The creamery plans to construct a new well; thus, continued independent withdrawals are expected. Wastewater is discharged to the Fargo municipal system.

Cass Rural Water Users Association, Kindred, North Dakota

The Cass Rural Water Users Association (CRWUA) supplies water to a large number of users -- both communities and individuals -- in Cass County, North Dakota. The CRWUA operates three separate well fields in the county, each with a respective service area. A West Fargo aquifer well field located about 4 miles southeast of Horace, North Dakota (in N1/2 Section 3, T137N, R49W), serves the Cass County area south of Argusville and east of Mapleton. Study area communities served by this well field are Mapleton, Briarwood, Frontier, North River, and a few homes in Reile's Acres. Argusville is supplied by another CRWUA well in western Cass County.

The 1980 total amount pumped from the well field near Horace was 153 million gallons. Actual or estimated water use by the study area communities in 1980 represents approximately 15 percent of this total, indicating most of the water withdrawn from this well field is delivered to individual users or other communities.

Future use of this well field depends on rural growth in the general Fargo area. The sum of projected populations for communities using CRWUA water was used as an indicator of rural growth. Projected annual withdrawals were assumed to increase from the 1980 amount in proportion to the projected rural population increase. Projected monthly withdrawals are assumed to occur in the average pattern observed between 1978 and 1980.

Dilworth, Minnesota

Dilworth obtains water from three municipal wells in the Kragnes aquifer. Projected water demands are based on the 1980 per capita use of 80 gallons per day and population projections. Pumping records were used to determine the average monthly percentage of total annual withdrawal during the period of 1978-1980. Projected monthly withdrawals were assumed to follow the average 1978-1980 pattern.

Dilworth wastewater is discharged to the Moorhead municipal system. This method of wastewater discharge is assumed to continue.

Fargo, North Dakota

Fargo obtains water from the Red River. In 1980, the total withdrawal was 3.78 billion gallons for a population of 61,281, indicating a per capita use of 169 gallons per day. Future water demands were projected from 1980 per capita use and population projections. Water withdrawal records were used to determine the average monthly percentages of total annual withdrawal during the period of 1979-1981. Projected monthly withdrawals were assumed to follow the 1979-1W81 pattern.

Fargo operates a wastewater lagoon system which discharges to the Red River. On the basis of 1979-1981 records, the average annual return flow is 75 percent of withdrawal. Projected return flows are assumed to be 75 percent of projected demands. Lagoon discharge records were used to determine the average monthly percentage of total annual discharge during the period of 1979-1981. Projected monthly discharges were assumed to follow the same pattern.

Frontier, North Dakota

Frontier residents receive water from the Cass Rural Water Users Association on an individual basis. Total water delivery records to Frontier were not available. Present (1980) and projected water demands were based on population projections and a per capita use of 70 gallons per day.

Individual septic systems are used for wastewater disposal in Frontier. As a result of the low present and projected water demand (about 0.02 cfs), return flow is assumed to be negligible.

Glyndon, Minnesota

Glyndon obtains municipal water from two wells in the Buffalo aquifer. Projected water demands were based on population projections and the 1980 per capita use of 109 gallons per day. Pumping records were used to determine the average monthly percentage of total annual withdrawal during the period 1979-1981. Projected monthly withdrawals were assumed to follow the 1979-1981 pattern.

Wastewater from Glyndon is pumped into a 7-acre primary lagoon. From there it enters a secondary 3-acre lagoon. Overflow is constant from the secondary lagoon. The overflow enters a creek that discharges to the Buffalo River. According to 1980 and 1981 records, about 78 percent of withdrawals are returned to the lagoons. It is assumed that future lagoon inflows will be 78 percent of projected demands and that 90 percent of the lagoon inflow is returned to the Buffalo River. Present and projected return flows are based on the equivalent assumption that 70 percent of annual withdrawals are returned to the Buffalo River on a constant discharge basis.

Harwood, North Dakota

Harwood obtains water from two wells in an undesignated aquifer. Projected demands were based on population projections and the 1980 per capita use of 79 gallons per day. Pumping records were used to determine the average monthly percentage of total annual withdrawal during the period 1979-1981. Projected monthly withdrawals were assumed to follow the 1979-1981 pattern.

Harwood operates a wastewater lagoon which discharges to the Red River via a drainage ditch. Lagoon discharges vary. During 1979-1981, four discharges occurred: three in 1979, none during 1980, and one in 1981. For the 3-year period of 1979-1981, the lagoon discharge averaged 44 percent of withdrawal. Projected return flows are assumed to be 44 percent of the projected annual demand. Lagoon discharges are assumed to occur in May and October of each year.

Held Beef Industries, West Fargo, North Dakota

Held Beef obtains water from two private wells in the West Fargo aquifer. West Fargo started metering the wells July 1980. Pumping data for the first 6 months of 1981 are assumed to be representative of the same period in 1980. Future water use is projected to be the same as that of 1980-81.

Horace, North Dakota

Horace obtains water from five wells in an undesignated aquifer. Demand projections were based on population projections and the 1980 per capita use of 59 gallons per day. Projected monthly demands were assumed to follow the 1980 pattern of monthly withdrawals.

Horace operates a wastewater lagoon that discharges to the Red River via a county drain. During 1980, two discharges of 980,100 gallons each occurred in April and November. This represents approximately 20 percent of water withdrawal for the year. Projected return flows are assumed to be 20 percent of projected demands, with two equal discharges occurring in April and November of each year.

Irrigation

Irrigation water demands were based on permit information. The demand for a given stream reach was assumed to include permitted surface water withdrawals and groundwater withdrawals within 1 mile of the stream. Projected average use is assumed to be 50 percent of the permit allocation. The North Dakota State Water Commission and Minnesota Department of Natural Resources consider 50 percent of the permit allotment to represent average long-term water use. Actual use in a particular year will vary. Withdrawals may equal the permit allotment during dry years; nominal withdrawals would be made during wet years.

Irrigation in the study area is normally done during the 5-month period May through September. Minnesota permits allow irrigation only during this period. As determined from North Dakota State Water Commission data for the Grand Forks-East Grand Forks Urban Study's water supply investigation, the average monthly percentages of total annual application are 4 percent in May, 8 percent in June, 41 percent in July, 30 percent in August, and 17 percent in September. Projected monthly irrigation water withdrawals are assumed to follow this pattern.

Irrigation return flows are assumed to be 20 percent of withdrawals. This percentage was obtained by comparing total irrigation water consumption and withdrawal in Minnesota during 1976 as determined by the Minnesota Water Planning Board (cited in Minnesota Department of Health, 1981). The return flow is assumed to return to the stream from which the water was withdrawn by means of shallow groundwater flow or surface runoff.

Projected irrigation demands are assumed to remain constant. This assumption is consistent with the method by which demands were assigned. A permit for surface water irrigation withdrawals cannot be obtained unless the irrigable land is adjacent to the stream. As a result of present surface water allocations to such landowners, additional permits are expected to allow only minor withdrawals, possibly dependent on streamflow conditions. Thus, future large-scale irrigation projects are expected to use groundwater sources away from streams.

Kragnes, Minnesota

Kragnes residents use individual wells and septic systems. The projected population for Kragnes is constant at 30 through the study period. Assuming a per capita water use of 90 gallons per day, the demand for Kragnes would be negligible (about 0.004 cfs). Return flow is also assumed to be negligible.

Livestock

Livestock water demands were based on a total use of 1.19 mgd over a 394-mile reach of the Red River as determined in 1976-77 for the Grand Forks-East Grand Forks Urban Study's water supply investigation. The resulting average livestock water use of 1.1 million gallons per year per river mile was used to assign demands to river reaches in the study area. Projected demands are assumed to remain constant.

Mapleton, North Dakota

Mapleton has received its total water supply from the Cass Rural Water Users Association since 1977. The previous source of water was the Maple River. Projected water demands are based on the 1980 per capita use of 80 gallons per day and population projections. Water delivery records were used to determine the average monthly percentage of total annual deliveries during 1978 and 1980. Projected monthly demands were assumed to follow the average 1978 and 1980 delivery pattern.

Mapleton operates a lagoon wastewater system which has not been discharged for about 5 years. It was constructed in anticipation of a mobile home court which was not developed. The lagoons are operating at about half capacity. Projected water use doubles by 2030, implying lagoon discharges may be required at that time. It is assumed that 20 percent of the projected 2030 demand is discharged to the Maple River during May and September. Zero discharge is assumed for the period before 2030.

Moorhead, Minnesota

Moorhead obtains water from the Red River, two wells in the Moorhead aquifer, and three wells in the Buffalo aquifer. The major commercial users of municipal water are the Anheuser-Busch malt plant and American Crystal Sugar.

The projected annual water demands for Moorhead are based on population projections and the 1980 per capita use of 143 gallons per day. As determined from 1979-1981 withdrawal records, the average percentages of Moorhead supply obtained from each of the three sources are 56 percent from the Red River, 31 percent from the Buffalo aquifer, and 13 percent from the Moorhead aquifer. These percentages were applied to projected annual Moorhead demands to determine the projected annual withdrawal from each source. Average monthly percentages of annual withdrawal from each source during 1979-1981 were computed from pumping records. Projected monthly withdrawals from each source are assumed to follow the 1979-1981 monthly withdrawal pattern.

Moorhead operates a wastewater treatment plant which serves both Moorhead and Dilworth. Discharge is to the Red River. Projected annual return flows are based on the average 1978-1981 annual discharge and are assumed to increase in proportion to combined projected populations of Moorhead and Dilworth. Average monthly percentages of total annual discharge during 1979-1981 were determined from discharge records. Projected monthly return flows are assumed to follow the average 1979-1981 pattern.

Moorhead Power Plant, Moorhead, Minnesota

The Moorhead Power Plant obtains water directly from the Red River. Water is used primarily for an evaporative steam cooling tower constructed in 1976. The plant is leased by a power generating agency and operates during peak overload demand periods, which usually occur in January, February, July, and August. The number of operating days per year has varied from 21 in 1977 to 238 in 1979 and averages 114 for the period 1977-1981. The plant operated for 88 days during 1980.

Under operating conditions, water is withdrawn from the Red River continuously at pump capacity (490 gpm). For the 1980 water demand, it was assumed that Red River withdrawals were made at intake pump capacity and that the 88 operational days were split evenly among the four months of peak demand -- January, February, July, and August. Projected demands are based on the same assumptions with the exception that the number of operational days each year was assumed to be 114, the average for the period of 1977-1981. The actual number of operational days during future years is expected to vary.

Return flow is expected to be negligible, since withdrawn water is used primarily for evaporative cooling.

North River, North Dakota

North River residents receive water from the Cass Rural Water Users Association on an individual basis. Records of total water delivery were not available. Present (1980) and projected water demands are based on population projections and a per capita use of 70 gallons per day.

Individual septic systems are used for wastewater disposal. Return flow is assumed to be negligible because of the low projected demand (0.01 to 0.03 cfs).

Prairie Rose, North Dakota

Prairie Rose residents obtain water from individual wells in an undesignated aquifer. Present (1980) and projected water demands are based on population projections and a per capita use of 70 gallons per day.

Individual septic systems are used for wastewater disposal. Return flow is assumed negligible because of the low projected demand (0.01 to 0.02 cfs).

Reile's Acres, North Dakota

Residents of Reile's Acres typically use one well to supply a few homes. Approximately 10 percent of the homes receive water from the Cass Rural Water Users Association. Water use records were not available. Present and projected water demands are based on a per capita use of 70 gallons per day and a present and projected population of 191.

Individual septic systems are used for wastewater disposal. Return flow is assumed to be negligible because of the low projected demand (0.02 cfs).

Riverside, North Dakota

Riverside obtains water from one city well in the West Fargo aquifer. City water is used for residential and commercial purposes. The largest commercial water user is the Cargill Sunflower Plant.

Withdrawal records for 1980 indicate a per capita use of 76 gallons per day by a population of 465. The projected population for 1990 through 2030 is constant at 600. However, much of Riverside is industrially zoned; thus, projected water use would be expected to increase as a result of industrial development. It is assumed in projecting demands that per capita use increases 10 percent each decade because of industrial development. Organized records on which monthly breakdowns of withdrawals could be based were not available. Projected monthly demands were assumed to be constant each year.

Riverside uses the wastewater treatment plant originally constructed for the Armour meat processing plant which ceased operations in the 1960's. Discharge from the treatment plant usually enters a holding pond which discharges to the Sheyenne River. When the Cargill Sunflower Plant is in full production, treatment plant discharge may be made directly to the river. No holding pond discharges occurred prior to late 1980 when Cargill began processing operations. Pond discharges are estimated to have occurred bimonthly on the average during 1981. Projected return flows are assumed to be 40 percent of withdrawals on the basis of the limited recent discharge information. Equal discharges are assumed to occur during the months of April, June, August, and October.

Riverside may connect to the West Fargo municipal sewer system in the future. The net effect of this change would be minor because West Fargo also discharges to the Sheyenne River and projected Riverside return flows are a small percentage of those projected for West Fargo.

Rustad, Minnesota

Rustad residents obtain water from individual wells in an undesignated aquifer. Present and projected water demands are based on a per capita use of 80 gallons per day and population projections.

Individual septic systems are used for wastewater disposal. Return flow is assumed negligible because of the low projected demand (0.01 cfs).

Sabin, Minnesota

Sabin obtains water from one unmetered well in the Buffalo aquifer. Present and projected water demands are based on population projections and a per capita water use of 90 gallons per day. Monthly withdrawals are assumed to follow the average 1979-1981 Glyndon pumping pattern.

Sabin operates a wastewater lagoon which is discharged in June and October. Lagoon effluent enters the Red River via a county ditch. Recent lagoon inflows and outflows are not known. As in the similar size community of Glyndon, return flow is assumed to be 70 percent of annual withdrawal. Equal return flows are assumed to occur in June and October.

Union Stockyards, West Fargo, North Dakota

Union Stockyards obtains water from two wells in the West Fargo aquifer. Water is used for watering cattle, hogs, and sheep and in the stockyards' office building. Water use at the stockyards has declined substantially -- from 135 million gallons in 1975 to 12.5 million gallons in 1981 because of implementation of an automatic watering system which supplies water to livestock when required, rather than at a constant rate. Projected demands are assumed to remain constant at the 1981 level. Actual future use may be less because of further improvements in water conservation.

Union Stockyards operates a lagoon wastewater system which discharges to the Sheyenne River. As a result of water conservation efforts, return flows are also declining. The annual discharge dropped from 36.1 million gallons in 1980 to 17.9 million gallons in 1981. Return flows are noted to exceed withdrawals during recent years. Projected return flows are assumed to remain constant at the 1981 figure. Actual future return flows may be less because of more efficient water use.

West Fargo, North Dakota

West Fargo obtains water from four wells in the West Fargo aquifer. Projected demands are based on the 1980 per capita use of 86 gallons per day and population projections. Pumping records were used to determine the average monthly percentages of total annual withdrawal during the period of 1979-1981. Projected monthly demands were assumed to follow the 1979-1981 average pattern.

Return flow from West Fargo consists of wastewater lagoon discharge to the Sheyenne River. Based on 6 years of discharge record (1972-1976 and 1980), return flows average about 80 percent of withdrawals. Projected return flows are assumed to be 80 percent of projected demands. Projected monthly discharges are assumed to occur similar to the average pattern of discharge during the 6 years of record.

APPENDIX II

EXAMPLE OF DEMAND PROJECTION CALCULATIONS
FARGO MUNICIPAL SYSTEM

Fargo obtains its municipal water supply from the Red River. As determined from withdrawal records, recent annual water use was as follows:

Year	Withdrawal (10^6 gal)	Population	Per Capita Use (gpd)
1981	3,529.9	62,000 (est.)	156 (est.)
1980	3,775.6	61,281	169
1979	3,643.7	60,437 (est.)	165 (est.)
1978	3,465.8	59,594 (est.)	159 (est.)
1975	2,878.4	57,063 (est.)	138 (est.)
1970	2,662.8	53,365	137

Projected annual demands based on population projections and 1980 per capita use of 169 gallons per day are:

Year	Projected Population	Projected Annual Demand (10^6 gal)
1990	66,700	4,114.4
2000	71,388	4,403.6
2030	99,500	6,137.7

Projected monthly demands are assumed to follow the average pattern of withdrawals which occurred during the period of 1979-1981. Monthly withdrawal volumes for this period are:

	Withdrawal (10^6 gal)		
Month	1979	1980	1981
Jan	278.3	244.0	259.3
Feb	321.0	247.9	226.2
Mar	336.8	253.8	251.9
Apr	289.5	324.7	279.1
May	301.0	465.9	375.9
Jun	332.3	321.1	304.0
Jul	335.3	497.7	387.1
Aug	325.8	348.7	360.4
Sep	337.1	279.6	290.7
Oct	294.4	267.3	269.8
Nov	250.0	263.5	266.7
Dec	242.3	261.6	258.8

The average monthly percentages of total annual withdrawals for the period of 1979-1981 are determined from the pumping records:

	Percentage of Total Withdrawal			
Month	1979	1980	1981	Average
Jan	8	6	7	7
Feb	9	7	6	8
Mar	9	7	7	8
Apr	8	9	8	8
May	8	12	11	10
Jun	9	9	9	9
Jul	9	13	11	11
Aug	9	9	10	9
Sep	9	7	8	8
Oct	8	7	8	8
Nov	7	7	8	7
Dec	7	7	7	7

Projected monthly demands are then obtained from the equation:

projected monthly demand (cfs) = 0.01547 x projected annual demand(10^6 gal) x avg. monthly % withdrawal / no. days in month.

Fargo return flows consist of wastewater lagoon discharges to the Red River. The following information is obtained from discharge records:

Year	Total Annual Discharge (10^6 gal)	Ratio of Discharge to Withdrawal
1981	2,742.7	0.78
1980	2,293.9	0.61
1979	3,115.3	0.85
1978	2,844.2	0.82
1975	3,184.0	1.11
1970	1,869.1	0.70

Projected annual return flows are assumed to be 75 percent of withdrawals on the basis of average ratio of discharge to withdrawals during 1979-1981. Thus, projected annual return flows are:

Year	Projected Demand (10^6 gal)	Projected Return Flow (10^6 gal)
1990	4,114.4	3,085.8
2000	4,403.6	3,302.7
2030	6,137.7	4,603.3

Projected monthly return flows are assumed to follow the average pattern of discharges which occurred during the period 1979-1981. Monthly discharges for this period are:

Month	Discharge (10^6 gal) 1979	1980	1981
Jan-Mar	0	0	0
Apr	105.5	0	377.7
May	384.4	613.0	418.3
Jun	741.5	321.9	0
Jul	0	0	666.3
Aug	504.3	307.0	0
Sep	233.2	377.3	0
Oct	440.7	0	443.8
Nov	512.1	485.8	607.6
Dec	193.7	188.9	229.0

The average monthly percentages of total annual discharges during 1979-1981 are determined from the discharge records:

Month	Percentage of Annual Discharge 1979	1980	1981	Average
Jan-Mar	0	0	0	0
Apr	4	0	14	6
May	12	27	15	18
Jun	24	14	0	13
Jul	0	0	24	8
Aug	16	13	0	10
Sep	8	16	0	8
Oct	14	0	16	10
Nov	16	21	22	19
Dec	6	9	9	8

Projected monthly return flows are then obtained from the equation:

$$\text{projected monthly return flow (cfs)} = 0.01547 \times \text{projected annual return flow } (10^6 \text{ gal}) \times \text{avg. monthly \% discharge / no. days in month.}$$

REFERENCES

PERSONAL COMMUNICATIONS

The following people provided information pertinent to the development of the water demand and return flow projections. Information from these sources was obtained through written correspondence, telephone conversation, or personal contact from 18 January through 3 March, 1982. For each person contacted, their affiliation and type of information provided are listed. The corresponding addresses and phone numbers for all persons contacted are listed by the community, industry, or organization they represent in table 4.

Beckman, Art, Cass-Clay Creamery.

General information pertaining to water use at the Cass-Clay Creamery.

Block, Jeff, Moore Engineering Incorporated, West Fargo, North Dakota.

Information pertaining to Riverside wastewater treatment facility.

Brussman, John, Busch Agricultural Resources.

Discussed future water use at Busch Agricultural Resources malt plant in Moorhead.

Buth, Harry, Sabin, Minnesota.

General information pertaining to water supply and wastewater systems and an estimate of present water use in Sabin.

Christianson, Rod, Cargill Sunflower Plant.

Records of private well withdrawals and past and future operating conditions.

Conway, Donna, North River, North Dakota.

General information pertaining to the water supply and wastewater systems in North River.

Cowden, Gary, Dilworth, Minnesota.

Dilworth city well pumping records.

Ertmann, Victor, Cass Rural Water Users Association (CRWUA).

Records of water deliveries to Mapleton and Briarwood and total withdrawals from the well field near Horace. Discussed general characteristics of CRWUA operations.

Fordyce, Ira, American Crystal Sugar.

Records of Red River withdrawals and discharges made by American Crystal Sugar. Future use of both city and independently withdrawn water.

Fuller, Richard, West Fargo, North Dakota.

Records of water withdrawals and lagoon discharges for West Fargo. Records of withdrawals made by Held Beef Industries from their private wells (metered by West Fargo).

Hanson, Mrs. Gerald, Argusville, North Dakota.

City well withdrawals, Cass Rural Water Users Association deliveries, and lagoon discharge information for Argusville.

Holm, James, Moorhead Power Plant.

Information pertaining to the Moorhead Power Plant operations. Red River intake pump capacity, and operating history from which water use estimates could be made.

Larson, Amy, Kragnes, Minnesota.

General information pertaining to the water supply and wastewater systems in Kragnes.

Mark, Sharon, Briarwood, North Dakota.

General information pertaining to the water supply and wastewater systems in Briarwood.

Matzke, Dale, Mapleton, North Dakota.

Information pertaining to the Mapleton wastewater lagoon.

McClain, Clifford, Moorhead, Minnesota.

Records of water withdrawals by Moorhead and annual deliveries made to major industries.

McClenathan, Sheila, North Dakota State Department of Health.

Return flow information for North Dakota communities in the study area and Union Stockyards.

Nelson, LaVerne, Frontier, North Dakota.

General information pertaining to the water supply and wastewater systems in Frontier.

Olson, Dee, Prairie Rose, North Dakota.

General information pertaining to water supply and wastewater systems in Prairie Rose.

Olson, Lloyd, Glyndon, Minnesota.

Glyndon well withdrawal and wastewater lagoon inflow records and the operational history of the lagoon.

Peloubet, Frank, Moorhead, Minnesota.

Records of discharge to the Red River by the Moorhead wastewater treatment plant.

Posey, Thomas, Mapleton, North Dakota.

General information pertaining to the water supply and wastewater systems in Mapleton.

Ruby, Kenneth, Fargo, North Dakota.

Water withdrawal and discharge records for Fargo.

Saude, Gerald, Horace, North Dakota.

Horace well withdrawal and wastewater lagoon discharge records.

Sinner, Eilene, Riverside, North Dakota.

Well withdrawal records and return flow information for Riverside.

Siverhus, Mike, Minnesota Pollution Control Agency.

Information pertaining to permitted discharges in the study area.

Smith, Michael, North Dakota State Water Commission.

Water permit and withdrawal information for North Dakota water users in the study area, including recent pumping records for Union Stockyards. Present and future irrigation water use in the study area.

Tanner, N.S., Harwood, North Dakota.

Harwood well withdrawal and wastewater lagoon discharge records.

Tareski, Val, Reile's Acres, North Dakota.

General information pertaining to water supply and wastewater systems in Reile's Acres.

Thomas, Lonnie, Minnesota Department of Natural Resources.

Discussed present and future irrigation water use in the study area.

Tourville, Elaine, Minnesota Department of Natural Resources.

Water permit information for Minnesota water users in the study area.

PUBLICATIONS

Minnesota Department of Health, "An Assessment of Minnesota Municipal Water Systems for Conservation Potential," March 1981.

Souris-Red-Rainy River Basins Commission, "Souris-Red-Rainy River Basins Comprehensive Study," 1972.

U.S. Army Corps of Engineers, St. Paul District, "Fargo-Moorhead Social and Environmental Inventory," February 1981.

U.S. Army Corps of Engineers, St. Paul District, "Grand Forks - East Grand Forks Urban Water Resources Study, Water Supply Appendix," July 1981.

TABLE 4

Summary of Personal Contacts
by Community, Industry, or Organization

Community, Industry, or Organization	Contact	Address	Telephone
American Crystal Sugar	Mr. Ira Fordyce, Manager, Environmental Control	101 North Third Street Moorhead, MN 56560	(218) 236-4492
Argusville, ND	Mrs. Gerald Hanson, Auditor	P.O. Box 104 Argusville, ND 58005	(701) 484-5308
Briarwood, ND	Ms. Sharon Mark, Auditor	22 Briarwood Place Fargo, ND 58103	(701) 237-5861
Busch Agricultural Resources	Mr. John Brussman, Vice President of Malt Operations	Busch Agricultural Res. 1 Busch Place St. Louis, MO 63118	(314) 577-2486
Cargill Sunflower Plant	Mr. Rod Christianson, Assistant Plant Superintendent	250-7th Avenue N.E. Riverside, ND 58078	(701) 282-8807
Cass-Clay Creamery	Mr. Art Beckman, Product General Manager	200 North 20th Street Fargo, ND 58105	(701) 293-6455
Cass Rural Water Users Association	Mr. Victor Ertmann, Manager	131 Maple Street Kindred, ND 58051	(701) 428-3139
Dilworth, MN	Mr. Gary Cowden, City Clerk	Box 187 Dilworth, MN 56529	(218) 287-2313
Fargo, ND	Mr. Kenneth Ruby, Director of Water Facilities	Box 1066 Fargo, ND 58107	(701) 241-1470
Frontier, ND	Ms. LaVerne Nelson, Auditor	Rural Route 1 Fargo, ND 58103	(701) 235-4192
Glyndon, MN	Mr. Lloyd Olson, City Clerk	Rural Route 2, Box 40B Glyndon, MN 56547	(218) 498-2578
Harwood, ND	Dr. N.S. Tanner	Room 210, Sudro Hall N.D. State University Fargo, ND 58105	(701) 237-7604
Horace, ND	Mr. Gerald Saude, Auditor	Box 641 Horace, ND 58047	(701) 293-4487

TABLE 4 (continued)

Community, Industry, or Organization	Contact	Address	Telephone
Kragnes, MN	Ms. Amy Larson, Auditor	Clay County Courthouse 807 North 11th Street Moorhead, MN 56560	(218) 299-5006
Mapleton, ND	Mr. Thomas Posey, Auditor	Mapleton, ND 58059	(701) 282-4433
	Mr. Dale Matzke	Mapleton, ND 58059	(701) 237-7911
Minnesota Department of Natural Resources	Ms. Elaine Tourville	444 Lafayette Road St. Paul, MN 55101	(612) 296-1423
	Mr. Lonnie Thomas	444 Lafayette Road St. Paul, MN 55101	(612) 296-0512
Minnesota Pollution Control Agency	Mr. Mike Siverhus	1935 West County Road B2 Roseville, MN 55113	(612) 296-7748
Moore Engineering, Inc.	Mr. Jeff Block	1042-14th Avenue East West Fargo, ND 58078	(701) 282-4692
Moorhead, MN	Mr. Clifford McClain	Water Treatment Plant 215-23rd Street North Moorhead, MN 56560	(218) 299-5471
	Mr. Frank Peloubet	Wastewater Treatment Plant 700-15th Avenue North Moorhead, MN 56560	(218) 299-5386
Moorhead Power Plant	Mr. James Holm	Moorhead Power Plant Moorhead, MN 56560	(218) 299-5418
North Dakota State Department of Health	Ms. Sheila McClenathan	Missouri Office Building 1200 Missouri Avenue Bismarck, ND 58505	(701) 224-2354
North Dakota State Water Commission	Mr. Michael L. Smith, Hydrologist	900 East Boulevard Bismarck, ND 58505	(701) 224-2754
North River, ND	Ms. Donna Conway, Auditor	Rural Route 2, Box 8CC Fargo, ND 58102	(701) 232-8114
Prairie Rose, ND	Ms. Dee Olson, Auditor	Rural Route 1, Box 9 Fargo, ND 58103	(701) 235-3974
Reile's Acres, ND	Mr. Val Tareski, Auditor	Box 2612 Fargo, ND 58108	(701) 237-7615

TABLE 4 (continued)

Community, Industry, or Organization	Contact	Address	Telephone
Riverside, ND	Ms. Eilene Sinner, Auditor	108 West Main Avenue Riverside, ND 58078	(701) 282-6221
Sabin, MN	Mr. Harold Buth, Mayor	Sabin, MN 56580	(218) 236-6333
West Fargo, ND	Mr. Richard Fuller, Water Superintendent	102 First Street West Fargo, ND 58078	(701) 282-3011

FARGO-MOORHEAD URBAN STUDY

WATER SUPPLY

PHASE 1, PART 2

LOW-FLOW ANALYSES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (contiued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

WATER SUPPLY/CONSERVATION INVESTIGATIONS FOR THE FARGO-MOORHEAD URBAN STUDY AREA, NORTH DAKOTA AND MINNESOTA

PHASE 1, PART 2: LOW-FLOW ANALYSES

I. SUMMARY

The need for an accurate assessment of future water supply and demand for the Fargo-Moorhead area (see Figure 1) has prompted the present study. This portion of the study focuses on surface water resources. Its objectives are a statistical description of streamflows (water supply) and a comparison with water demands. Demands for the study area were developed in the "Phase 1, Part 1: Water Demand Projections" report (March 1982).[1] The streamflow statistics are based on output developed by the St. Paul District of the Corps of Engineers from the Hydrologic Engineering Center HEC-3 computer program. For two small streams, monthly streamflows were derived from regional correlations using the HEC-4 computer program. Partial duration analyses were performed on monthly streamflow data for 10 potential supply points in the study area. The results were used to generate nonsequential mass curves (frequency-mass curves) of water supply, and these were compared with average annual demands for alternative water supply schemes.

Two sets of analyses are presented. The first reflects year 2030 water demands. Based on statistics for a 50-year recurrence interval drought, year 2030 demands are predicted to exceed surface water supplies in the study area. The total additional storage required to balance supplies and demands is in the range of 2,000 to 2,500 acre-feet for the best alternative supply

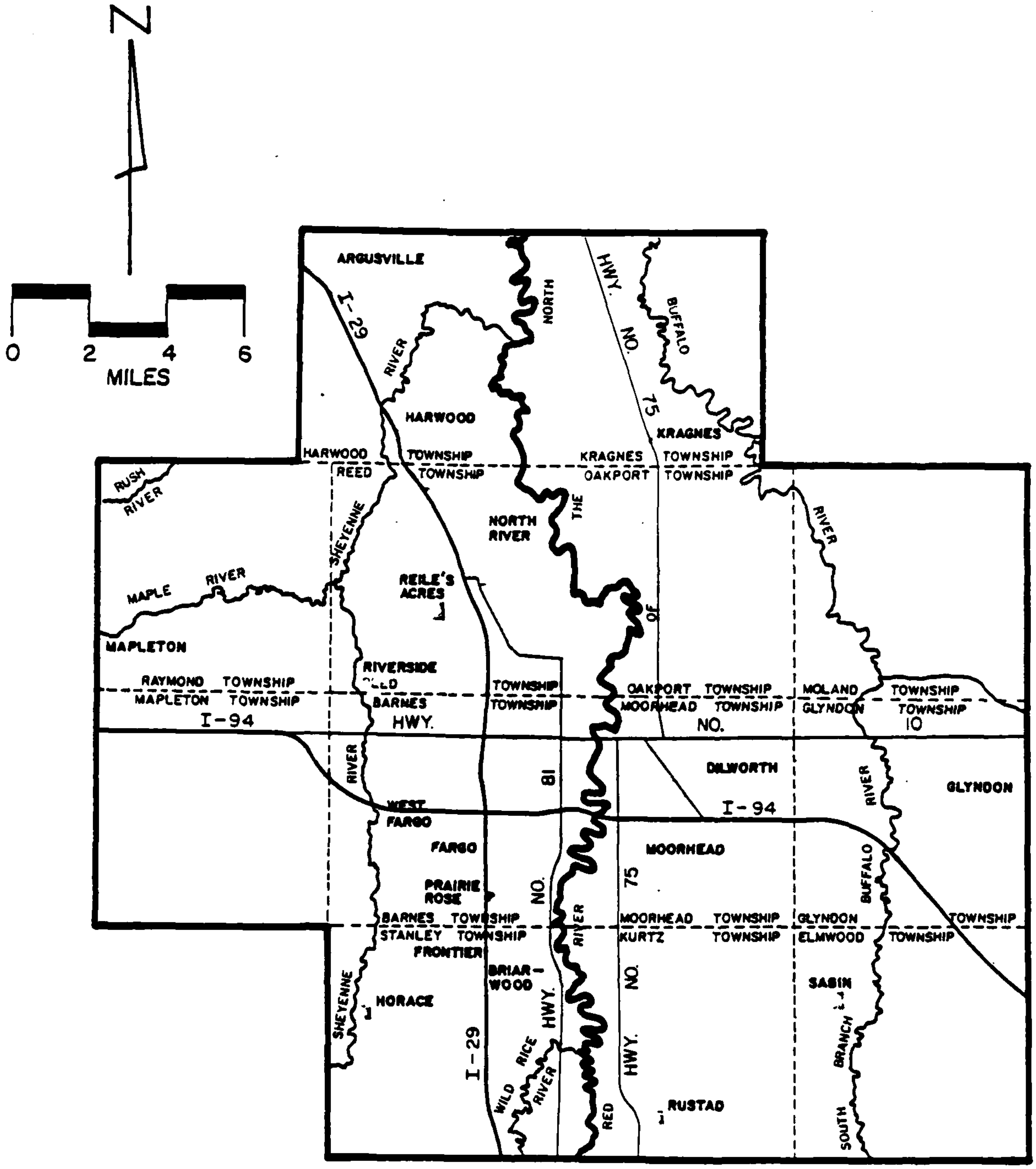


FIGURE 1: Fargo - Moorhead Study Area

schemes. Because of the substantial excess of projected demands over surface water supplies, the second set of analyses is based on actual year 1980 demands. Water shortages are again predicted for 50-year drought conditions if all 1980 demands were to be met with surface water supplies. The total additional storage needed in this case is in the 1,000 to 1,200 acre-foot range for the best supply schemes. Within the study area, minimum in-stream flow requirements set in 1972 for the Red and Sheyenne Rivers are 7 and 3 cubic feet per second (cfs), respectively. Of the total additional storage needs, the in-stream flow requirements generally accounty for 55 to 60 percent in the year 2030 case and 25 to 40 percent for 1980.

Flow rate comparisons (based on 7-day low streamflows and average demands) show total shortages of 32 cfs for the best schemes in the 2030 case and 21 cfs for the best schemes in 1980. Of these totals, the minimum in-stream flow requirements account for 7 cfs for the Red River in both cases, and for the Sheyenne River, 2.5 to 3 cfs for 2030 and 1 to 3 cfs for 1980. For a 100-year recurrence interval drought, the additional storage volumes and flow shortages are generally within 10 percent of the 50-year recurrence interval results.

In 1984, the City of Fargo completed the "Sheyenne pipeline," connecting the Sheyenne River directly to the Fargo water treatment plant. This pipeline is designed to replace the "Sheyenne diversion," an open ditch that was previously used to transfer water indirectly

from the Sheyenne River to Fargo via the Red River. The pipeline has the same capacity (approximately 25 cfs) as the maximum diversion used formerly and will be operated in the same manner.

The analyses discussed in the body of this report utilize streamflow data that include the effects of the Sheyenne diversion. The recent construction of the Sheyenne pipeline will reduce flows in the Red River of Fargo. Low-flow frequency curves for the Red River at Fargo that display the effect of the Sheyenne pipeline were subsequently developed. Curves for year 1980 and year 2030 conditions are included in Appendix A, along with the supporting partial duration analyses data.

The purpose of this portion of the study is to determine whether the area's surface water supplies are capable of meeting water demands. The manner in which water is acquired from the Sheyenne River does not affect conclusions in this phase of the study. In later phases, the effect of the Sheyenne pipeline is considered.

The low-flow analyses lead to the conclusion that total reliance on surface waters in the Fargo-Moorhead study area would carry a real danger of water shortages under present demand conditions. This danger increases substantially over the next 50 years. Careful regional planning of water supply is therefore warranted for this area. Planning must consider all possible water sources, including groundwater, the Garrison Diversion, and additional reservoir storage, as well as existing surface water and other supplies. Demand reduction must also be considered.

II. NEEDS AND OBJECTIVES

The present water supply/conservation investigations for the Fargo-Moorhead urban study area comprise a broad-view, three-phase study of the area's future water supply options. The study is avoiding preconceived notions based on existing facilities and is evaluating all reasonable alternative water sources and supply systems.

The objective in Phase 1 is to consider whether the area's surface waters could meet the area's water demands and, if not, the amount of demand reduction and/or supplemental supply needed. Specifically, Phase 1 aims to determine whether flows in selected study area rivers -- the Red River of the North, Sheyenne River, Maple River, Buffalo River, and South Branch Buffalo River -- are adequate to meet anticipated water supply demands during a severe drought in the 1980-2030 planning period. Part 1 of Phase 1 projected water demands for the planning period for industries, agricultural interests, and the 18 municipalities in the study areas. Part 2, the portion of the study reported on here, includes river low-flow analyses and comparisons between supply and demand.

Phase 2 will involve development of more detailed, disaggregated water demand projections for the study area and evaluation of alternative raw water sources and water treatment/distribution systems. Phase 3 will focus on water conservation and drought contingency measures.

III. PROCEDURES

Introduction

The various methods for comparing water supply and demand have in common the utilization of mass curves. In hydrologic analysis, a mass curve is a graph of accumulated flow (i.e., time-integral of flow) versus time. The vertical scale measures volumes, so the conventional name "mass curve" is imprecise. The curves provide determinations of storage volumes needed for drought periods.

Three methods are available for supply/demand comparisons and storage determinations. The earliest method, the Flow-Mass Curve analysis,[2] uses a mass curve based directly on a historical streamflow record. The demand of interest is represented by a straight line whose slope equals the demand in flow units. Demand "curves" (lines) are drawn tangent to the supply mass curve at relative high points and extended forward in time until intersecting the supply curve. In each case, the maximum divergence between the supply and demand lines -- measured as a vertical line -- represents the storage needed for a corresponding drought period. In usual applications, the largest storage volume determined from the historical record is used as a basis for reservoir design.

The Frequency, or Nonsequential, Mass Curve analysis is a probabilistic method.[3 4] A drought with a certain recurrence interval (inversely related to its probability of occurrence) is represented by a synthetic supply mass curve. This mass curve is derived from low-flow frequency curves giving the average

streamflow for droughts of various durations and probabilities (frequencies) of occurrence. Statistical analysis of the historical streamflow record yields the low-flow frequency curves. The supply mass curve is then synthesized by assuming that the low flows of various durations (7-day, 14-day, 1-month, 2-month, etc.) are equal to the average streamflow during the corresponding initial periods of the drought. This procedure tends to maximize the upward concavity of the supply mass curve. As in the first method of analysis, the average demand is represented as a straight line of certain slope. However, there is only one demand line, and it intersects the origin of the graph. Where the demand line is higher than the supply curve, the maximum vertical difference again determines the storage requirement.

The third method, the Storage Deficiency-Frequency-Mass Curve analysis,[5 6] is also probabilistic. In this method, the storage volumes (deficiencies) are determined from the historical flow mass curve, just as in the Flow-Mass Curve method. But rather than simply selecting the largest storage volume, the various storage volumes are ranked and statistically analyzed. The result is a storage deficiency-frequency curve, from which one can read the storage needed for any desired drought frequency or recurrence interval.

The more recent probabilistic methods are preferrable for studies such as the present one, since rational planning and decision-making require the assignment of definite recurrence

intervals. Of the two probabilistic methods, the Storage Deficiency method has the advantage of allowing the incorporation of seasonal demand variation, although this adds complexity and cost to the analysis. The Frequency-Mass Curve analysis is widely used and accepted and can be performed using existing, well-tested computer programs. For these reasons, the Frequency-Mass Curve method is the procedure selected for this study.

Streamflow Records

Ten potential supply points were analyzed, as shown schematically in Figure 2. For eight of these points, the streamflow record is derived from output of the Hydrologic Engineering Center HEC-3 computer program, "Reservoir System Analysis for Conservation".[7] The HEC-3 model takes actual historical streamflow records and makes adjustments to account for reservoir operation, diversions, withdrawals for water supply and other purposes, and return flows. It is based on monthly average streamflow values.

Dam and reservoir construction during the historical period of streamflow record in the present study is a primary reason for using the HEC-3 model; the model can simulate streamflows which would have occurred if the reservoirs had been operated throughout the whole period of record. This type of adjustment is necessary to produce a homogeneous streamflow record for analysis. In addition, the HEC-3 model can simulate conditions with projected future demands and return flows superimposed on the homogeneous historical record. Such simulations also incorporate rules for reservoir operation.

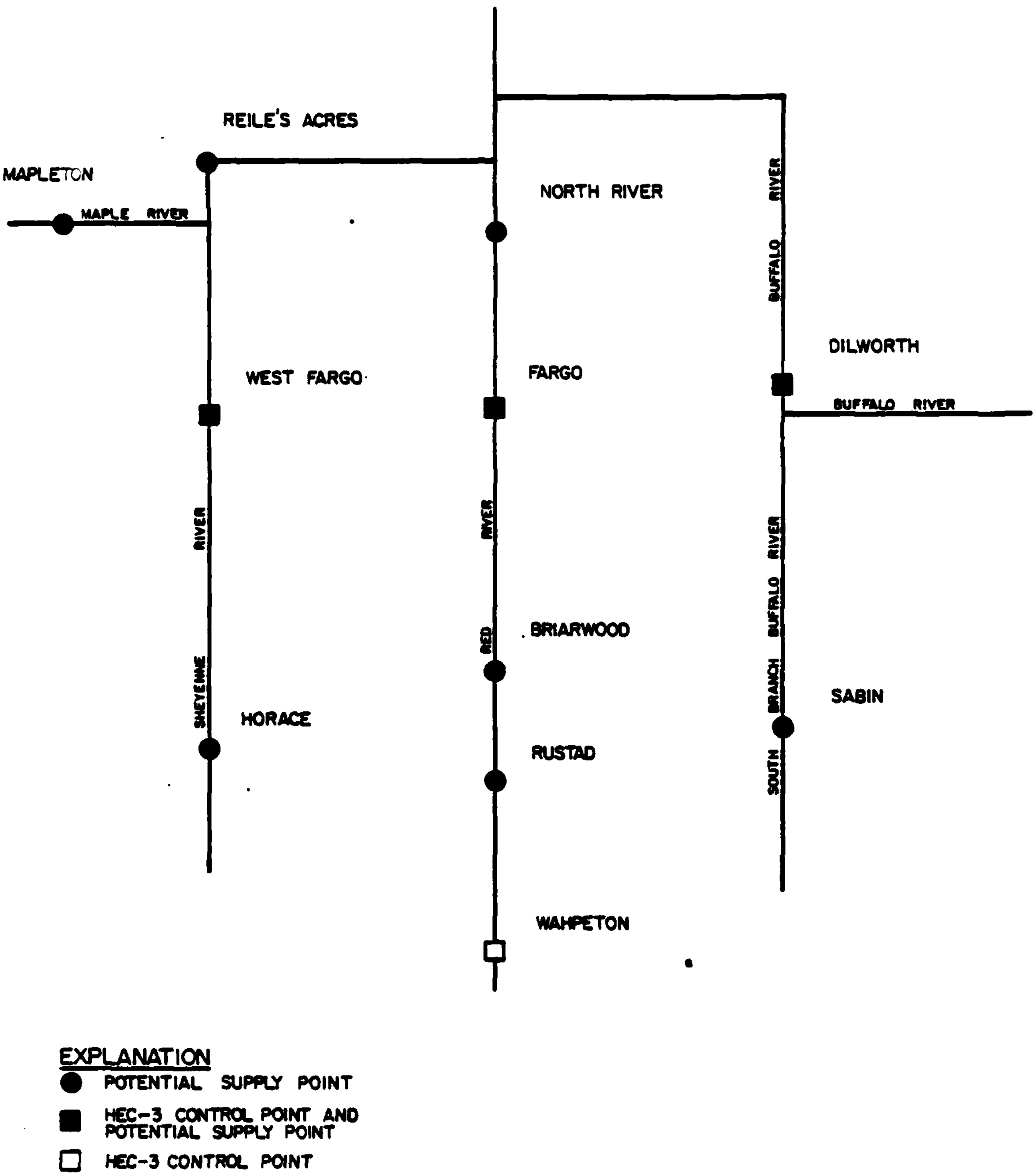


FIGURE 2: Schematic of HEC-3 Control Points and Potential Supply Points

The HEC-3 output used for the eight supply points in this analysis reflects upstream reservoir operation, the diversion of 25 cfs from the Sheyenne to the Red River during peirods of insufficient flow in the Red and other effects under specified demand conditions. The HEC-3 modeling work was performed in 1976-77 by the St. Paul District of the Corps of Engineers.

The eight streamflow records were derived from output data for four HEC-3 control points (see Figure 2). For this purpose, further adjustments were made to the HEC-3 output to account for intervening withdrawals and return flows. These further adjustments reflect newly developed demands and return flows.[1] Minor inconsistencies result because reservoir operation in the HEC-3 simulation was based on projections developed in 1976-77 by the Corps of Engineers. However, the newly developed demands are considered more accurate because they use populaton data and other relevant information available as recently as March 1982. The HEC-3 data adjustments are detailed in Appendix B. Data adjustments required for later analyses considering the effect of the Sheyenne pipeline on Red River flows are described in Appendix A.

The period of record used in the HEC-3 simulations is October 1929 to September 1976. This 47-year period includes the severe drought of the 1930's, believed to be a very rare event. There will be more discussion of this below.

The two remaining potential supply points are on small, unregulated tributaries not included in the HEC-3 simulations (Maple River at Mapleton and South Branch Buffalo River at Sabin). Streamflow measurements at these points begain in the

mid-1940's. The records were completed for the 47-year period through regional correlations, using the Hydrologic Engineering Center HEC-4 computer program, "Monthly Streamflow Simulations".[8] The program statistically analyzes monthly flow records of streams in a given region. It produces initial correlation coefficients for pairs of stream gaging stations, with values ranging between +1.0 (denoting perfect correlation -- essentially, a proportionality between two flow records) and -1.0 (for perfect negative correlation). The value 0.0 indicates no correlation whatsoever, or complete independence of the flows. Initial correlations provide guidance in selecting stations for the next step of analysis, the reconstitution of streamflow records. In analyzing a regional set of stations, the HEC-4 program reconstitutes, or estimates, monthly streamflow values for all missing data in the station records. All records are completed for the period beginning with the earliest measured flow (considering all the stations) and ending with the latest measured flow. The estimates are based on the statistical relationships among the station flow records.

After examining the characteristics of all the records of U.S. Geological Survey gaging stations in the upper watershed of the Red River of the North (some 28 stations), data were obtained for 11 stations for purposes of initial correlations. One of these stations was discarded because of a preponderance of zero flows (the drainage area was only a few square miles). Initial correlations were run with the remaining stations, as tabulated in Appendix B.

Reconstitution of streamflows for the South Branch Buffalo River at Sabin then proceeded in two steps: (1) records for the Wild Rice (Minnesota) and Buffalo Rivers were used to extend the South Branch Buffalo River's record back through August 1930, and (2) the final extension (through October 1929) was accomplished with the Red River at Fargo record. To avoid adverse impacts on correlations from regulation by Orwell Dam, records more recent than February 1953 were excluded for the Red River.

A similar procedure was followed for the Maple River at Mapleton: (1) the record was extended back through April 1931 and forward through the water year 1976 using the Wild Rice (North Dakota), Maple (at Enderlin) and Goose Rivers, and (2) the earliest part of the record was completed using the Sheyenne River at West Fargo. The Sheyenne River record after July 1949 was excluded to avoid regulation by the Baldhill Dam.

Partial Duration Analyses

Partial duration analyses were performed for the 10 potential supply points for low-flow durations of 7 days, 14 days, 1 month, 2 months, 3 months, 4 months, 6 months, 9 months, 12 months, 2 years, 4 years, and 8 years. In a partial duration analysis, the streamflow record is examined to determine the lowest average flow of a given duration, followed by the second lowest average flow of the duration, then the third lowest, and so on. A statistical formula relates the rank and record length to each flow's probability (expressed as either an exceedence frequency or recurrence interval). The results are plotted, and smooth curves for each duration are drawn through the data points.

In this study, Beard's Method[9] was used to analyze durations of 1 month and greater. This method selects events without regard to calendar year and in such way as to insure the independence of all events with a given duration (i.e., no overlap is allowed). After the low-flow events are selected and ranked, the rank 1 (lowest-flow) event is assigned the exceedence frequency P defined by:

$$P = 1 - (.5)^{1/N} \tag{1}$$

in which:

N = effective record length in years.

(For example, a 47-year record being analyzed for 9-month duration low flows has an effective record length of 47 years minus 8 months, or N = 46.33 years, because of the nonoverlapping constraint.) For other ranks, exceedence frequencies PP are linearly interpolated according to:

$$PP = P + (\Delta R) \left(\frac{\Delta P}{\Delta I}\right) \tag{2}$$

Where:

ΔR = rank number minus 1;

$\Delta P = (.5)^{1/N} - P$; and

$\Delta I = N-1$.

The exceedence frequencies P and PP in equations (1) and (2) are computed as decimal fractions, and in this form the corresponding recurrence interval in years is simply the inverse of the frequency.

The Hydrologic Engineering Center computer program "Partial Duration - Independent Low Flow Events"[10] was used for analyzing durations greater than 1 month. An exactly analogous computer

program was developed to analyze 1-month durations. Durations of 7 and 14 days required a different approach, since monthly (not daily) streamflows constituted the basic input data for the analyses.

To investigate 7- and 14-day low flows, daily streamflows obtained for the regional correlations (see above) were used to determine ratios between monthly low flows and the shorter duration low flows within each month. The ranges of monthly low flows used in determining the ratios were restricted on the basis of the partial duration analysis results for 1-month durations for each river. For example, the 1-month low flows for the Buffalo River at Dilworth range from zero to approximately 5 cfs (see Figure 11). Therefore, monthly flows in this range were used to determine the ratios. Similarly, 1-month low flows for the Sheyenne River generally range below 10 cfs (see Figures 3-5), so this was the range used for the Sheyenne. The 20 lowest-flow months of record were used in computing the ratios for the Buffalo and Sheyenne Rivers, as these approximated the above ranges. (A few months were excluded because of zero monthly flow or because all daily flows were artificially reported as being exactly equal to the average flow for the month.)

The Red River exhibits a much wider range of 1-month low flows, approximately 5-40 cfs (see Figures 7-10), necessitating a different approach. To cover the flow-range of interest, the 70 lowest-flow months of record (after excluding 15 months with zero flow) were required. A graphical analysis revealed a trend in the sought-after ratios, with the ratios increasing as monthly flow

increased. Accordingly, the flow-range was subdivided. The divisions were selected to yield fairly constant ratios over each subrange of flow.

The ratios resulting from this analysis follow:

River	Range of Flows	Ratio of Low Flows	
		7-day:1-month	14-day:1-month
Red	<12.00 cfs	.099	.314
	12.01 to 36.06 cfs	.575	.739
	≥36.07 cfs	.781	.858
Sheyenne	All flows of interest	.715	.793
Buffalo	All flows of interest	.605	.655
South Branch Buffalo	All 1-month and 7- and 14-day low flows of interest are zero.		
Maple	All 1-month and 7- and 14-day low flows of interest are zero.		

The 7- and 14-day low flows for the 10 potential supply points were determined by applying the above ratios to the 1-month duration low flows found by Beard's Method. The frequency recurrence interval determined for each 1-month flow were assigned to the corresponding shorter duration flows.

Appendix C contains tabulated results of the partial duration analyses. The results appear in graphical form in Figures 3-12 and 47-54, Low-Flow Frequency Curves. (Appendix A contains Figures A-1 and A-2, Low-Flow Frequency Curves for the Red River at Fargo with the Sheyenne Pipeline. It also includes tabulated results of the respective partial duration analyses.) In the graphs, the horizontal scale (recurrence interval) is defined according to the Gumbel probability distribution, as described by Chow.[11] Figures 3-12 and 47-54 reflect graphical smoothing of the computed data points. They also reflect two further adjustments.

First, as previously mentioned, the period of record analyzed includes the severe 1930's drought. Investigations of this drought indicate a large recurrence interval for it. The U.S. Geological Survey found that the Red River low flows of the 1930's probably have not been matched in severity for at least 150 years.[12] The Corps of Engineers has performed a simulation analysis of Red River flows, concluding that a recurrence interval of 200 years is reasonable and should be assigned to the minimum flows of the 1930's. By contrast, the partial duration analyses gave computed recurrence intervals of 57-68 years. Therefore, the low-flow frequency curves were adjusted accordingly.

Finally, the longer duration (2- to 8-year) low flows required adjustment because of the short period of record relative to their durations. With a relatively short record, the analytical procedure (Beard's Method) sometimes gives low flows for the longer durations which exceed the average streamflow for the period of record. The curve adjustment procedure used for the longer duration flows is described in the report entitled, Kansas Streamflow Characteristics, Part 4, Requirements to Sustain Gross Reservoir Outflow.[13]

Mass Curves

Frequency-mass curves were developed for drought flows of 20-, 50-, and 100-year recurrence intervals. The procedure for a given supply point is to read flow values from the family of low-flow frequency curves (refer to any of Figures 3-12) along the vertical line of the desired recurrence interval. The flow values are

converted to mass equivalents (i.e., volumes or cumulative flows) by multiplying with the corresponding duration, expressed in days. The frequency-mass curve is then a plot of the resulting mass values (in mixed units of cfs-days) versus time (corresponding durations).

Frequency-mass curves were produced for the 10 potential supply points and for various combinations of points. To combine two points, the flows of identical duration and recurrence interval were added and the masses then computed by multiplying with the durations. As a check, the masses of identical duration and recurrence interval (previously computed for the individual points) were also added to obtain the same results.

This procedure for combining supply points is inherently conservative. It assumes that a drought of given severity (as measured by recurrence interval) occurs simultaneously in different streams. In reality, this is unlikely. For example, the Buffalo River could have moderate streamflow during a severe drought in, say, the Sheyenne River.

Another way of stating the assumption is to say that streamflows throughout the study area are 100 percent dependent on one another. An indication of the actual degree of dependence is given by the results of the regional correlations performed as part of this study (see Appendix B). These results show correlation coefficients typically in the range .5 to .8, compared with 1.0 for 100 percent dependence. Thus, the assumption used in combining control points appears to be both reasonable and conservative.

Figures 13-46 and 55-88 show the resulting mass curves for the year 2030 and year 1980 analyses, respectively. Demand curves in the figures are straight lines representing projected 2030 or actual 1980 average annual demands, including municipal, industrial, and agricultural uses.[1] Demands in certain cases also include minimum in-stream flow requirements, as discussed in the next section.

Observations on Procedures

The procedures used in this study are largely the same as those used and discussed in the July 1981 Grand Forks - East Grand Forks Urban Water Resources Study appendix entitled, "Stage 3 Low-Flow Frequency Analysis".[14] The evaluation of procedures presented there (pages 14-16) applies to the present study as well. In particular, it is noteworthy that a 10-percent safety margin is appropriate for storage requirements determined by Frequency-Mass Curve analysis, because of a reported bias toward underestimation. All storage volumes in the present study were increased by 10 percent for this reason.

IV. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

Two low-flow analyses are reported here. The first analysis assumes projected year 2030 water demands. The second reflects water demands for 1980. The water demands used in the analyses are those which were developed in Phase 1, Part 1 of the present study. They reflect the best information available as of late 1982.

As previously discussed, the monthly streamflow data used in the analyses were derived from historic flow records. The derived data records assume the current operating plans for Lake Ashtabula (at Baldhill Dam) and Orwell Reservoir were maintained throughout the period of record (October 1929 through September 1976). The two reservoirs were actually constructed in the early 1940's and early 1950's, respectively.

The low-flow analyses for the Red River at Fargo reflect operation of the Sheyenne diversion to the Red River rather than the newly completed Sheyenne pipeline. Prior to 1984, the normal operation was to divert 25 cfs from the Sheyenne to the Red during periods when Red River flow was less than or equal to 10 cfs below Fargo-Moorhead. The diversion was a short distance upstream from the water intakes of Fargo and Moorhead. Low-flow frequency curves reflecting Sheyenne pipeline operation are presented in Appendix A; however, further analyses using these results were not undertaken. The manner in which water is acquired from the Sheyenne does not affect conclusions in this phase of the study.

Supply/demand imbalances were examined in two ways. First, additional storage volumes needed to balance supply and demand were determined from the mass curves. The procedures for this have been described previously. Note that the present analysis does not account for evaporation from new reservoirs built to meet additional storage needs.

Second, flow rates were compared to determine demand reductions or additional flows needed to balance supply and demand. Theoretically, supply and demand exactly balance when the demand mass curve (a straight line in this analysis) is tangent to the supply mass curve at the origin. However, since the supply mass curve is a hand-fitted curve through discrete points (the origin plus points at 7 days, 14 days, 1 month, and so on), fitting a tangent line at the origin is not an objective procedure. An objective and practical approach in the present context is to consider supply and demand to balance when the demand line passes through the 7-day point of the supply mass curve. (In this case, the demand line cuts a secant which approximates the theoretical tangent to the supply mass curve.) This is equivalent to saying that the demand just equals the 7-day low flow. Thus, "flow shortages" were developed on this basis as differences between 7-day low streamflows and average demands. The flow shortages could be considered to represent either demand reductions or additional flows needed. The flow rate comparisons, since they rely solely on 7-day low-flows, are more conservative than the storage determinations.

The 1972 report, "Souris-Red-Rainy River Basins Comprehensive Study".[15] established minimum in-stream flow requirements of 7 cfs for the Red River below Fargo-Moorhead and 3 cfs for the Sheyenne River below West Fargo. These were established "to provide a safety factor for the water needs analysis and insure that some minimal river flow is maintained below each withdrawal point."

For this reason, supply/demand imbalances specifically resulting from the in-stream flow requirements were examined for the Red and Sheyenne Rivers.

A single critical supply point was selected on each river for this analysis. The critical points were identified as the Red River at Fargo-Moorhead and the Sheyenne River at West Fargo, the two major withdrawal points in the study area. Measures taken to insure in-stream flows here would also satisfy in-stream needs at other points downstream.

In order to investigate in detail the relationships between supplies and demands in the study area, 11 alternative supply/demand configurations were defined. These are shown in Table 1 - Assignment of Community Demands for Alternatives Studied. The first three alternatives rely completely on individual supply points. The last alternative is the most extreme regional case. The remaining ones have various degrees of regionalization.

In the following subsections, the results of the low-flow analyses for study years 2030 and 1980 are presented and compared.

Year 2030 Results

The low-flow analyses reported here assume projected year 2030 water demands, as developed in Phase 1, Part 1 of the present study. The demands total approximately 46 cubic feet per second (cfs) for the study area. Projections developed by the Corps in

TABLE 1

Assignment of Community Demands For Alternatives Studied

Supply Point	Supply/Demand Alternative 1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	Horace	Horace	Horace	Horace	Horace	Horace	Horace	Horace	Horace	Horace	–
Sheyenne at West Fargo	West Fargo Riverside	West Fargo Riverside	West Fargo Riverside	–	–	–	–	–	–	–	–
Sheyenne at Reile's Acres	Reile's Acres, Harwood, Argusville	Reile's Acres, Harwood, Argusville	Reile's Acres, Harwood, Argusville	Reile's Acres, Harwood, Argusville	Reile's Acres, Harwood, Argusville	Reile's Acres, Harwood, Argusville	Reile's Acres, Harwood, Argusville	Reile's Acres, Harwood, Argusville	Reile's Acres, Harwood, Argusville	Reile's Acres, Harwood, Argusville	–
Maple at Mapleton	Mapleton	Mapleton	Mapleton	Mapleton	Mapleton	Mapleton	–	–	–	–	–
Red at Rustad	Rustad	Rustad	Rustad	Rustad	Rustad	Rustad	Rustad	Rustad	Rustad	Rustad	–
Red at Briarwood	Briarwood Frontier	Briarwood Frontier	Briarwood Frontier	Briarwood Frontier	Briarwood Frontier	Briarwood Frontier	Briarwood Frontier	Briarwood Frontier	Briarwood Frontier	Briarwood Frontier	–
Red at Fargo	Fargo Moorhead Dilworth Prairie Rose	Fargo Prairie Rose	Fargo Moorhead Prairie Rose	–	–	–	Fargo Moorhead Prairie Rose	–	–	–	–
Red at North River	North River Kragnes	North River	North River Kragnes	North River Kragnes	North River Kragnes	North River Kragnes	North River Kragnes	North River Kragnes	North River Kragnes	North River Kragnes	– –
Buffalo at Dilworth	Glyndon	Moorhead Dilworth Glyndon Kragnes	Dilworth Glyndon	Dilworth Glyndon	–	Glyndon	Dilworth Glyndon	Dilworth Glyndon	–	Glyndon	–
So.Br.Buffalo at Sabin	Sabin	Sabin	Sabin	Sabin	Sabin	Sabin	Sabin	Sabin	Sabin	Sabin	–
Red at Fargo + Sheyenne at West Fargo	–	–	–	Fargo Moorhead Prairie Rose West Fargo Riverside	–	Fargo Moorhead Prairie Rose Dilworth West Fargo Riverside	–	–	–	–	–

TABLE 1 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	–	–	–	–	Fargo Moorhead, Prairie Rose, Dilworth, Glyndon, West Fargo, Riverside	–	–	–	–	–	–
Sheyenne at West Fargo + Maple at Mapleton	–	–	–	–	–	–	West Fargo, Riverside , Mapleton	–	–	–	–
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	–	–	–	–	–	–	–	Fargo, Moorhead, Prairie Rose, West Fargo, Riverside, Mapleton	–	Fargo, Moorhead, Prairie Rose, Dilworth, West Fargo, Riverside, Mapleton	–
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	–	–	–	–	–	–	–	–	Fargo, Moorhead, Prairie Rose, Dilworth, Glyndon, West Fargo, Riverside, Mapleton	–	–
Red at Rustad + Sheyenne at Horace + Buffalo at Dilworth + Maple at Mapleton	–	–	–	–	–	–	–	–	–	–	All 18 Communities

1976-77 totaled 55 cfs, based on a larger year 2030 population estimate for Fargo. The Phase 1, Part 1 projections are used here because they reflect the best information available as of late 1982.

Table 2 lists the year 2030 average annual water demands corresponding to the 11 alternative supply/demand configurations studied. (Refer to Table 1 - Assignment of Community Demands for Alternatives Studied.) The demands include all municipal, industrial, irrigation, and livestock water use. However, the only demands "moved" in the analysis of alternatives are municipal demands (including municipally served industries).

The results of the partial duration analyses appear in Figures 3-12 - Low-Flow Frequency Curves. Figures 3-12 are identified as corresponding to the year 2030 because for each point they reflect upstream water demands, return flows, and reservoir and diversion operation for year 2030 conditions. The curves depict discharge-frequency relationships for low-flow events of various durations. For example, the curves show that the 3-month low flows at the 50-year recurrence interval are less than 36 cfs in the Red River at Fargo, less than 10 cfs in the Sheyenne River at West Fargo, less than 2 cfs in the Buffalo River at Dilworth, and zero in the Maple and South Branch Buffalo Rivers. These total less than 48 cfs of available supply. The total for 7-day low flows is less than 25 cfs. Thus, with year 2030 demands, substantial water shortages could occur if the study area relied completely on surface water supplies with the existing reservoirs.

TABLE 2

Average Annual Demands (cubic feet per second) Projected For Year 2030

	Supply/Demand Alternative										
Supply Point	1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	-
Sheyenne at West Fargo	4.32	4.32	4.32	-	-	-	-	-	-	-	-
Sheyenne at Reile's Acres	.22	.22	.22	.22	.22	.22	.22	.22	.22	.22	-
Maple at Mapleton	.48	.48	.48	.48	.48	.48	-	-	-	-	-
Red at Rustad	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	-
Red at Briarwood	.62	.62	.62	.62	.62	.62	.62	.62	.62	.62	-
Red at Fargo	37.88	27.34	37.34	-	-	-	37.34	-	-	-	-
Red at No. River	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	-
Buffalo at Dilworth	.45	10.99	.99	.99	-	.45	.99	.99	-	.45	-
So.Br.Buffalo at Sabin	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	-
Red at Fargo + Sheyenne at West Fargo	-	-	-	41.66	-	42.20	-	-	-	-	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	-	-	-	-	42.65	-	-	-	-	-	-
Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	4.80	-	-	-	-

TABLE 2 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne @ West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	42.14	-	42.68	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	-	43.13	-	-
Red at Rustad + Sheyenne at Horace + Buffalo at Dilworth + Maple at Mapleton	-	-	-	-	-	-	-	-	-	-	45.62
TOTALS	45.62	45.62	45.62	45.62	45.62	45.62	45.62	45.62	45.62	45.62	45.62

NOTE: Only municipal demands are moved for the different alternatives; irrigation, livestock and independent withdrawals by industry assumed to stay on river where now located.

Figures 13-46 present mass curves of water supply, derived from the low-flow frequency curves, along with supply/demand comparisons for the alternatives defined above. The shape of the mass supply curves is generally concave upward. Curves for the Red River at Fargo have a somewhat anomalous curvature, however, near the 1-month duration. This appears to be an effect of the Sheyenne diversion, which operates only during low-flow periods. Two supply/demand comparisons are shown for some supply points on the Red and Sheyenne Rivers. One assumes no minimum in-stream flow requirement, and the other includes the specified requirement (7 cfs for the Red, 3 cfs for the Sheyenne) in the demand line. The minimum in-stream flow requirements will be discussed subsequently.

Figures 13-34 indicate the additional storage volumes needed to balance supply and demand without considering in-stream flow requirements. Tables 3 and 4 are compilations of these results for droughts of 50-year and 100-year recurrence intervals.

Flow shortages (defined as differences between 7-day low streamflows and average water demands) are shown in Tables 5 and 6. Again, these do not reflect in-stream flow requirements. The flow shortages represent either demand reductions or additional flows needed.

Table 7 summarizes the additional storage needs from Tables 3 and 4 (column totals). Alternatives 8-10 have the smallest additional storage needs, ranging from 940-980 acre-feet (50-year recurrence interval). These alternatives take advantage

TABLE 3

Year 2030 Additional Storage (acre-feet) Needed for Water Supply - 50-Year Recurrence Interval Drought

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	0	0	0	0	0	0	0	0	0	0	-
Sheyenne at West Fargo	0	0	0	-	-	-	-	-	-	-	-
Sheyenne at Reile's Acres	0	0	0	0	0	0	0	0	0	0	-
Maple at Mapleton	200	200	200	200	200	200	-	-	-	-	-
Red at Rustad	0	0	0	0	0	0	0	0	0	0	-
Red at Briarwood	0	0	0	0	0	0	0	0	0	0	-
Red at Fargo	600	160	550	-	-	-	550	-	-	-	-
Red at No. River	0	0	0	0	0	0	0	0	0	0	-
Buffalo at Dilworth	20	3300	60	60	-	20	60	60	-	20	-
So.Br.Buffalo at Sabin	500	500	500	500	500	500	500	500	500	500	-
Red at Fargo + Sheyenne at West Fargo	-	-	-	420	-	440	-	-	-	-	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	-	-	-	-	440	-	-	-	-	-	-
Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	0	-	-	-	-

TABLE 3 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	420	-	460	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	-	440	-	-
Red at Rustad + Sheyenne at Horace + Buffalo at Dilworth + Maple at Mapleton	-	-	-	-	-	-	-	-	-	-	4500

NOTE: Storage needed for minimum in-stream flows not included.
Year 2030 demands.

TABLE 4

Year 2030 Additional Storage (acre-feet) Needed for Water Supply - 100-Year Recurrence Interval Drought

Supply Point	Supply/Demand Alternative 1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	0	0	0	0	0	0	0	0	0	0	-
Sheyenne at West Fargo	0	0	0	-	-	-	-	-	-	-	-
Sheyenne at Reile's Acres	0	0	0	0	0	0	0	0	0	0	-
Maple at Mapleton	200	200	200	200	200	200	-	-	-	-	-
Red at Rustad	0	0	0	0	0	0	0	0	0	0	-
Red at Briarwood	0	0	0	0	0	0	0	0	0	0	-
Red at Fargo	750	180	660	-	-	-	660	-	-	-	-
Red at No. River	0	0	0	0	0	0	0	0	0	0	-
Buffalo at Dilworth	35	3500	90	90	-	35	90	90	-	35	-
So.Br.Buffalo at Sabin	520	520	520	520	520	520	520	520	520	520	-
Red at Fargo + Sheyenne at West Fargo	-	-	-	440	-	480	-	-	-	-	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	-	-	-	-	480	-	-	-	-	-	-
Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	0	-	-	-	-

AD-A157 283 FARGO-MOORHEAD URBAN STUDY WATER SUPPLY APPENDIX VOLUME 2/5
1 PHASE 1 PART 1..(U) CORPS OF ENGINEERS ST PAUL MN ST
PAUL DISTRICT MAY 85

UNCLASSIFIED F/G 13/2 NL

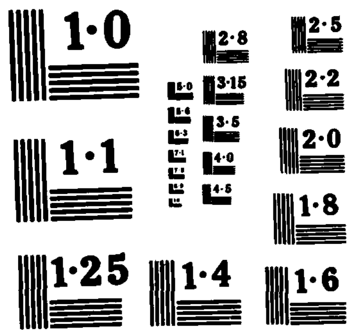

1·0
2·8
2·5
3·15
2·2
3·5
2·0
4·0
1·1
4·5
1·8
1·25
1·4
1·6

TABLE 4 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	440	-	480	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple ay Mapleton	-	-	-	-	-	-	-	-	480	-	-
Red at Rustad + Sheyenne at Horace + Buffalo at Dilworth + Maple at Mapleton	-	-	-	-	-	-	-	-	-	-	5000

NOTE: Storage needed for minimum in-stream flows not included.
Year 2030 demands.

TABLE 5

Year 2030 Demand Reductions or Additional Flows (cfs) Needed for Water Supply
50-Year Recurrence Interval Drought

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	0	0	0	0	0	0	0	0	0	0	-
Sheyenne at West Fargo	0	0	0	-	-	-	-	-	-	-	-
Sheyenne at Reile's Acres	0	0	0	0	0	0	0	0	0	0	-
Maple at Mapleton	.48	.48	.48	.48	.48	.48	-	-	-	-	-
Red at Rustad	0	0	0	0	0	0	0	0	0	0	-
Red at Briarwood	0	0	0	0	0	0	0	0	0	0	-
Red at Fargo	19.68	9.14	19.14	-	-	-	19.14	-	-	-	-
Red at No. River	0	0	0	0	0	0	0	0	0	0	-
Buffalo at Dilworth	.45	10.99	.99	.99	-	.45	.99	.99	-	.45	-
So.Br.Buffalo at Sabin	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	-
Red at Fargo + Sheyenne at West Fargo	-	-	-	18.66	-	19.20	-	-	-	-	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	-	-	-	-	19.65	-	-	-	-	-	-
Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	0	-	-	-	-

TABLE 5 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	19.14	-	19.68	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	-	20.13	-	-
Red at Rustad + Sheyenne at Horace + Buffalo at Dilworth + Maple at Mapleton	-	-	-	-	-	-	-	-	-	-	43.21

NOTE: No allowance is made for minimum in-stream flow requirements. Year 2030 demands. Values reflect difference between demand and 7-day low streamflow.

TABLE 6

Year 2030 Demand Reductions or Additional Flows (cfs) Needed for Water Supply
100-Year Recurrence Interval Drought

Supply Point	Supply/Demand Alternative 1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	0	0	0	0	0	0	0	0	0	0	-
Sheyenne at West Fargo	0	0	0	-	-	-	-	-	-	-	-
Sheyenne at Reile's Acres	0	0	0	0	0	0	0	0	0	0	-
Maple at Mapleton	.48	.48	.48	.48	.48	.48	-	-	-	-	-
Red at Rustad	0	0	0	0	0	0	0	0	0	0	-
Red at Briarwood	0	0	0	0	0	0	0	0	0	0	-
Red at Fargo	19.88	9.34	19.34	-	-	-	19.34	-	-	-	-
Red at No. River	0	0	0	0	0	0	0	0	0	0	-
Buffalo at Dilworth	.45	10.99	.99	.99	-	.45	.99	.99	-	.45	-
So.Br.Buffalo at Sabin	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	-
Red at Fargo + Sheyenne at West Fargo	-	-	-	18.96	-	19.50	-	-	-	-	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	-	-	-	-	19.95	-	-	-	-	-	-
Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	0.10	-	-	-	-

TABLE 6 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	19.44	-	19.98	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	-	20.43	-	-
Red at Rustad + Sheyenne at Horace + Buffalo at Dilworth + Maple at Mapleton	-	-	-	-	-	-	-	-	-	-	43.34

NOTE: No allowance is made for minimum in-stream flow requirements. Year 2030 demands. Values reflect difference between demand and 7-day low streamflow.

TABLE 7

Summary of Additional Storage Needed for Water Supply - Year 2030

	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
50-Yr. Recurr. Int. (ac-ft)	1,320	4,160	1,310	1,180	1,140	1,160	1,110	980	940	980	4,500
100-Yr. Recurr. Int. (ac-ft)	1,505	4,400	1,470	1,250	1,200	1,235	1,270	1,050	1,000	1,035	5,000
Ratio 100-Yr: 50-Yr.	1.14	1.06	1.12	1.06	1.05	1.06	1.14	1.07	1.06	1.06	1.11

NOTE: Storage needed for minimum in-stream flows not included.
Year 2030 demands

of local in-flows between the upstream study area boundary and the major withdrawal points (Fargo-Moorhead and West Fargo) by regionalizing the supply points where the major withdrawals occur. Storage needs based on 100-year recurrence interval results are within 15 percent of the 50-year values. The present analysis does not account for evaporation from new reservoirs to meet additional storage needs; evaporation would cause some increase in actual storage requirements.

Table 8 summarizes needed demand reductions or additional flows (i.e., flow shortages) from Tables 5 and 6. There is almost no variation in the totals for alternatives 1-10, the flow shortage being approximately 22 cfs in all cases. The regional case (alternative 11) has a flow shortage nearly twice as large (43 cfs), however, because it assumes supply only near the upstream boundary of the study area.

As previously noted, minimum in-stream flow requirements of 7 cfs for the Red River and 3 cfs for the Sheyenne River within the present study area were established in 1972. From all the analysis above, none of the Sheyenne River's individual supply points requires additional storage or flows for water supply purposes alone. However, when the minimum in-stream flow requirements are considered, water shortages occur at supply points on both the Red and Sheyenne Rivers.

TABLE 8

Summary of Demand Reductions or Additional Flows Needed for Water Supply - Year 2030

	Supply/Demand Alternative		
	1-3	4-10	11
50-Year Recurrence Interval (cfs)	22.0	21.5	43.2
100-Year Recurrence Interval (cfs)	22.2	21.8	43.3
Ratio 100-Year: 50-Year	1.01	1.01	1.002

NOTE: No allowance is made for minimum in-stream flow requirements. Year 2030 demands. Values reflect difference between demand and 7-day low streamflow.

The critical supply points identified for analysis in this regard are the Red River at Fargo-Moorhead and the Sheyenne River at West Fargo, the two major withdrawal points in the study area. Table 9 shows the additional storage needed (apart from storage for water supply, as previously given in Tables 3 and 4) to meet minimum in-stream flow requirements. These results are based on the two critical points mentioned, except in the case of alternative 11. This alternative uses only the most upstream supply points (Rustad on the Red and Horace on the Sheyenne River), so these are the basis for the storage needs in this case. The results in Table 9 were derived from Figures 35-46 (in which the demand lines include the in-stream flow requirements) by subtracting the storage volumes previously determined for water supply only. Storage in excess of 1,000 acre-feet is needed in most alternatives. And again, this is strictly for in-stream flows, not for water supply.

Table 10 gives the shortages due to in-stream requirements in terms of flow rates. As before (Tables 5 and 6), the 7-day low flows are the basis for the flow shortages. The total shortages are 10 cfs, or nearly so, in all cases.

Tables 11 and 12 summarize the results of the suppy/demand comparisons for year 2030 demands and existing reservoir and diversion operation. In terms of storage (Table 11), alternatives 8-10 have the smallest additional needs. These generally range from 2,000-2,500 acre-feet, of which minimum in-stream flow requirements account for 55-60 percent. Storage needs for the 100-year recurrence interval are generally within 10 percent of the 50-year needs.

TABLE 9

Additional Storage (acre-feet) Needed to Meet Minimum In-Stream Flows - Year 2030

	Supply/Demand Alternative										
Supply Point	1	2	3	4	5	6	7	8	9	10	11
Sheyenne at West Fargo	65* (70)**	65 (70)	65 (70)	-	-	-	-	-	-	-	-
Red at Fargo	1,400 (1,400)	180 (180)	1,250 (1,250)	-	-	-	1,250 (1,250)	-	-	-	-
Red at Fargo + Sheyenne at West Fargo	-	-	-	1,080 (1,260)	-	1,160 (1,320)	-	-	-	-	-
Red at Fargo + Buffalo at Dilworth + Sheyenne W.Fargo	-	-	-	-	1,160 (1,320)	-	-	-	-	-	-
Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	90 (100)	-	-	-	-
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	1,180 (1,360)	-	1,340 (1,520)	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	-	-	-	1,360 (1,520)	-	-
Red at Rustad + Sheyenne at Horace + Buffalo at Dilworth + Maple at Mapleton	-	-	-	-	-	-	-	-	-	-	1,900 (2,000)
50-Yr. R.I. Totals	1,465	245	1,315	1,080	1,160	1,160	1,340	1,180	1,360	1,340	1,900
100-Yr. R.I. Totals	1,470	250	1,320	1,260	1,320	1,320	1,350	1,360	1,520	1,520	2,000

* 50-Year recurrence interval drought
** 100-Year recurrence interval drought

NOTE: Storage needed for water supply not included but indirectly reflected. Year 2030 demands.

TABLE 10

Demand Reductions or Additional Flows (cfs) Needed to Meet Minimum In-Stream Flows - Year 2030

	Supply/Demand Alternative						
Supply Point	1-3	4 & 6	5	7	8 & 10	9	11
Sheyenne at West Fargo	2.5* (2.6)**	-	-	-	-	-	-
Red at Fargo	7.0 (7.0)	-	-	7.0 (7.0)	-	-	-
Red at Fargo + Sheyenne at West Fargo	-	10.0 (10.0)	-	-	-	-	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	-	-	10.0 (10.0)	-	-	-	-
Sheyenne at West Fargo + Maple at Mapleton	-	-	-	3.0 (3.0)	-	-	-
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	10.0 (10.0)	-	-
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	-	-	-	-	-	10.0 (10.0)	-
Red at Rustad + Sheyenne at Horace + Buffalo at Dilworth + Maple at Mapleton	-	-	-	-	-	-	10.0 (10.0)
50-Yr. Recurr. Int. Totals	9.5	10.0	10.0	10.0	10.0	10.0	10.0
100-Yr. Recur. Int. Totals	9.6	10.0	10.0	10.0	10.0	10.0	10.0
Ratio 100-Yr:50-Yr.	1.01	1	1	1	1	1	1

*50-year recurrence interval drought
**100-year recurrence interval drought

NOTE: Year 2030 demands. Values reflect difference between demand and 7-day low streamflow.

TABLE 11

Summary of Total Additional Storage Needs - Year 2030

Water Need	Supply/Demand Alternative 1	2	3	4	5	6	7	8	9	10	11
Water Supply (ac-ft)	*1,320	4,160	1,310	1,180	1,140	1,160	1,110	980	940	980	4,500
	**(1,505)	(4,400)	(1,470)	(1,250)	(1,200)	(1,235)	(1,270)	(1,050)	(1,000)	(1,035)	(5,000)
In-Stream Flow (ac-ft)	*1,465	245	1,315	1,080	1,160	1,160	1,340	1,180	1,360	1,340	1,900
	**(1,470)	(250)	(1,320)	(1,260)	(1,320)	(1,320)	(1,350)	(1,360)	(1,520)	(1,520)	(2,000)
50-Yr R.I. Totals (ac-ft)	2,785	4,405	2,625	2,260	2,300	2,320	2,450	2,160	2,300	2,320	6,400
100-Yr R.I. Totals (ac-ft)	2,975	4,650	2,790	2,510	2,520	2,555	2,620	2,410	2,520	2,555	7,000
Ratio 100-Yr: 50-Yr	1.07	1.06	1.06	1.11	1.10	1.10	1.07	1.12	1.10	1.10	1.09

*50-year recurrence interval drought
**100-year recurrence interval drought

NOTE: Year 2030 demands.

TABLE 12

Summary of Total Demand Reduction or Additional Flow Needs - Year 2030

	Supply/Demand Alternative		
	1-3	4-10	11
Water Supply (cfs)	22.0* (22.2)**	21.5 (21.8)	43.2 (43.3)
In-Stream Flow (cfs)	9.5* (9.6)**	10.0 (10.0)	10.0 (10.0)
50-Year Recurrence Interval (cfs)	31.5	31.5	53.2
100-Year Recurrence Interval (cfs)	31.8	31.8	53.3
Ratio 100-Year: 50-Year	1.01	1.01	1.002

* 50-year recurrence interval drought

** 100-year recurrence interval drought

NOTE: Year 2030 demands. Values reflect difference between demand and 7-day low streamflow.

The three least-storage alternatives regionalize the demands from Fargo, Moorhead, Prairie Rose, West Fargo, Riverside and Mapleton and regionalize supplies from the Red River at Fargo, Sheyenne River at West Fargo, and Maple River at Mapleton (see Table 1).

In terms of flow rate (Table 12) the alternatives are indistinguishable except for the regional alternative 11, which requires two-thirds again as much flow as the others. The total demand reduction or additional flow needed is approximately 32 cfs for alternatives 1-10. One-third of this is for in-stream flow requirements. The flow shortages are practically the same for the 50-year and 100-year recurrence intervals.

Year 1980 Results

The low-flow analyses discussed here are based on actual year 1980 water demands, as developed in Phase 1, Part 1 of the present study. Their annual average total for the study area is approximately 29 cfs. This is about 2 cfs higher than the study area total which was projected by the Corps in 1976-77 for the year 1980.

The potential of surface water to satisfy the demands of the study area was evaluated by considering the same 11 alternatives previously considered (Table 1 - Assignment of Community Demands for Alternatives Studied). Table 13 lists the year 1980 average annual water demands corresponding to the alternatives listed in Table 1. Again, the demands include all municipal, industrial, irrigation, and livestock water use. However, the only demands "moved" in the analysis of alternatives are municipal demands (including municipally served industries).

TABLE 13

Average Annual Demands (cubic feet per second) for Year 1980

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	--
Sheyenne at West Fargo	2.48	2.48	2.48	--	--	--	--	--	--	--	--
Sheyenne at Reile's Acres	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	--
Maple at Mapleton	0.44	0.44	0.44	0.44	0.44	0.44	--	--	--	--	--
Red at Rustad	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	--
Red at Briarwood	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	--
Red at Fargo	23.6	16.63	23.28	--	--	--	23.28	--	--	--	--
Red at No. River	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	--
Buffalo at Dilworth	0.42	7.39	0.74	0.74	--	0.42	0.74	0.74	--	0.42	
So. Br. Buffalo at Sabin	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	--
Red at Fargo + Sheyenne at West Fargo	--	--	--	25.76	--	26.08	--	--	--	--	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	--	--	--	--	26.50	--	--	--	--	--	--
Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	2.92	--	--	--	--

TABLE 13 (continued)

Supply Point	Supply/Demand Alternative 1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	26.20	--	26.52	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	--	26.94	--	--
Red at Rustad + Sheyenne at + Buffalo at at Dilworth + Maple at Mapleton	--	--	--	--	--	--	--	--	--	--	29.21
TOTALS	29.21	29.21	29.21	29.21	29.21	29.21	29.21	29.21	29.21	29.21	29.21

NOTE: Storage needed for minimum in-stream flows not included.
Year 1980 demands.

The results of the partial duration analyses for the year 1980 case are displayed in Figures 47-54 - Low-Flow Frequency Curves. The figures are similar to Figures 3-5 and 7-11 for the year 2030 case. (For the Maple River at Mapleton and the South Branch Buffalo River at Sabin, Figures 6 and 12, respectively, show results applicable for both the 2030 and 1980 cases.)

Generally, the streamflows plotted in the low-flow frequency curves might be expected to be higher for the year 1980 case because of smaller water withdrawals upstream of the study area. In fact, the mean monthly flows, shown at the tops of Figures 3-12 and 47-54, bear this out. The mean flows for the 1980 case are greater than those for 2030 at all supply points along the Red River, and are greater than or equal to those for 2030 at all other supply points. The mean flows reflect the total mass or volume of water discharged over the 47-year period of analysis. Thus, the comparison of mean flows shows the effects of smaller upstream withdrawals in the 1980 case.

For certain supply points, however, comparison of low streamflows of short duration seems to contradict the above. The Sheyenne River at Horace and at West Fargo, and the Red River at Fargo and at North River all have low-flow frequency curves for durations of 2 months or less which are higher for the 2030 case than for 1980, at least at some recurrence intervals.

The apparent contradiction is the result of streamflow regulation during drought periods. The demands at Fargo-Moorhead and at West Fargo are greater for the year 2030 (approximately 37 cfs and

4.3 cfs, respectively) than for the year 1980 (approximately 23 cfs and 2.5 cfs, respectively). Reservoir and diversion operation therefore is such as to ensure flows at Fargo-Moorhead and at West Fargo, during the most extreme droughts, which are higher for the 2030 case than for 1980.

It is primarily the operation of Baldhill Dam, on the Sheyenne River, and of the Sheyenne diversion to the Red River which affects the West Fargo, Fargo, and North River supply points. Baldhill Dam operation also affects the Sheyenne River supply point at Horace.

Operation of Orwell dam, with a much smaller reservoir, has relatively little effect on the downstream Red River supply points. This is evidenced by the low-flow frequency curves for Rustad and Briarwood. These Red River supply points are above the diversion from the Sheyenne River, and their low-flow frequency curves do not show the apparent anomaly noted for the Fargo and North River supply points, located below the diversion.

The low-flow frequency curves in Figures 47-54 indicate that surface waters, if totally relied upon at present, would be inadequate for supply under drought conditions. For example, the streamflows of the Red River at Fargo, Sheyenne River at West Fargo, Buffalo River, South Branch Buffalo River, and Maple River total less than 18 cfs under 50-year, 7-day low-flow conditions.

Figures 55-88 present year 1980 mass curves and supply-demand comparisons for the 11 alternatives. The figures indicate the additional storage volumes needed to balance supply and demand. As in the year 2030 case, two comparisons are shown for some supply points on the Red and Sheyenne Rivers. One asusmes no minimum in-stream flow requirement, and the other includes the minimum requirement in the demand line. The storage volumes determined from Figures 55-88 for the 50-year and 100-year recurrence intervals are compiled in Tables 14 and 15. The results in these tables do not reflect in-stream flow requirements.

Tables 16 and 17 present supply/demand imbalances in terms of demand reductions or additional flows needed. As before, these flow shortages represent differences between 7-day low streamflows and demands. The values in Tables 16 and 17 do not reflect in-stream flow requirements.

Table 18 summarizes the addiitonal storage needs from Tables 14 and 15. Alternatives 8-10 have the smallest additional storage needs, ranging from 620 to 635 acre-feet (50-year recurrence interval). These alternatives reduce the required maximum storage by regionalizing water supplies and demands. Streamflows in excess of any regional withdrawal point's monthly demand are pooled and used to avert shortages at other interconnected communities within the region. Storage needs based on 100-year recurrence interval results are within 10 percent of the 50-year values.

TABLE 14

Year 1980 Additional Storage (acre-feet) Needed for Water Supply - 50-Year Recurrence Interval Drought

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	0	0	0	0	0	0	0	0	0	0	--
Sheyenne at West Fargo	0	0	0	--	--	--	--	--	--	--	--
Sheyenne at Reile's Acres	0	0	0	0	0	0	0	0	0	0	--
Maple at Mapleton	180	180	180	180	180	180	--	--	--	--	--
Red at Rustad	0	0	0	0	0	0	0	0	0	0	--
Red at Briarwood	0	0	0	0	0	0	0	0	0	0	--
Red at Fargo	290	80	260	--	--	--	260	--	--	--	--
Red at No. River	0	0	0	0	0	0	0	0	0	0	--
Buffalo at Dilworth	4	1,100	16	16	--	4	16	16	--	4	--
So. Br. Buffalo at Sabin	430	430	430	430	430	430	430	430	430	430	--
Red at Fargo + Sheyenne at West Fargo	--	--	--	180	--	180	--	--	--	--	
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	--	--	--	--	190	--	--	--	--	--	--
Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	0	--	--	--

TABLE 14 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	190	--	190	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	--	190	--	--
Red at Rustad + Sheyenne at + Buffalo at at Dilworth + Maple at Mapleton	--	--	--	--	--	--	--	--	--	--	790

NOTE: Storage needed for minimum in-stream flows not included.
Year 1980 demands.

TABLE 15

Year 1980 Additional Storage (acre-feet) Needed for Water Supply - 100-Year Recurrence Interval Drought

Supply Point	Supply/Demand Alternative 1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	0	0	0	0	0	0	0	0	0	0	--
Sheyenne at West Fargo	0	0	0	--	--	--	--	--	--	--	--
Sheyenne at Reile's Acres	0	0	0	0	0	0	0	0	0	0	--
Maple at Mapleton	180	180	180	180	180	180	--	--	--	--	--
Red at Rustad	0	0	0	0	0	0	0	0	0	0	--
Red at Briarwood	0	0	0	0	0	0	0	0	0	0	--
Red at Fargo	300	90	290	--	--	--	290	--	--	--	--
Red at No. River	0	0	0	0	0	0	0	0	0	0	--
Buffalo at Dilworth	14	1,600	30	30	--	14	30	30	--	14	--
So. Br. Buffalo at Sabin	460	460	460	460	460	460	460	460	460	460	--
Red at Fargo + Sheyenne at West Fargo	--	--	--	190	--	190	--	--	--	--	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	--	--	--	--	210	--	--	--	--	--	--
Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	0	--	--	--	--

TABLE 15 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	200	--	200	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	--	220	--	--
Red at Rustad + Sheyenne at + Buffalo at at Dilworth + Maple at Mapleton	--	--	--	--	--	--	--	--	--	--	880

NOTE: Storage needed for minimum in-stream flows not included. Year 1980 demands.

TABLE 16

Year 1980 Demand Reductions or Additional Flows (cfs) Needed for Water Supply
50-Year Recurrence Interval Drought

Supply Point	Supply/Demand Alternative 1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	0	0	0	0	0	0	0	0	0	0	--
Sheyenne at West Fargo	0	0	0	--	--	--	--	--	--	--	--
Sheyenne at Reile's Acres	0	0	0	0	0	0	0	0	0	0	--
Maple at Mapleton	.44	.44	.44	.44	.44	.44	--	--	--	--	--
Red at Rustad	0	0	0	0	0	0	0	0	0	0	--
Red at Briarwood	0	0	0	0	0	0	0	0	0	0	--
Red at Fargo	11.30	4.33	10.98	--	--	--	10.98	--	--	--	--
Red at No. River	0	0	0	0	0	0	0	0	0	0	--
Buffalo at Dilworth	.27	7.24	.59	.59	--	.27	.59	.59	--	.27	--
So. Br. Buffalo at Sabin	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	--
Red at Fargo + Sheyenne at West Fargo	--	--	--	8.78	--	9.1	--	--	--	--	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	--	--	--	--	9.37	--	--	--	--	--	--
Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	0	--	--	--	--

TABLE 16 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	9.22	--	9.54	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	--	9.81	--	--
Red at Rustad + Sheyenne at + Buffalo at at Dilworth + Maple at Mapleton	--	--	--	--	--	--	--	--	--	--	18.78

NOTE: No allowance is made for minimum in-stream flow requirements. Year 1980 demands. Values reflect difference between demand and 7-day low streamflow.

TABLE 17

Year 1980 Demand Reductions or Additional Flows (cfs) Needed for Water Supply
100-Year Recurrence Interval Drought

Supply Point	Supply/Demand Alternative 1	2	3	4	5	6	7	8	9	10	11
Sheyenne at Horace	0	0	0	0	0	0	0	0	0	0	--
Sheyenne at West Fargo	0	0	0	--	--	--	--	--	--	--	--
Sheyenne at Reile's Acres	0	0	0	0	0	0	0	0	0	0	--
Maple at Mapleton	.44	.44	.44	.44	.44	.44	--	--	--	--	--
Red at Rustad	0	0	0	0	0	0	0	0	0	0	--
Red at Briarwood	0	0	0	0	0	0	0	0	0	0	--
Red at Fargo	11.60	4.63	11.28	--	--	--	11.28	--	--	--	--
Red at No. River	0	0	0	0	0	0	0	0	0	0	--
Buffalo at Dilworth	.42	7.39	.74	.74	--	.42	.74	.74	--	.42	--
So. Br. Buffalo at Sabin	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	--
Red at Fargo + Sheyenne at West Fargo	--	--	--	9.16	--	9.48	--	--	--	--	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	--	--	--	--	9.90	--	--	--	--	--	--
Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	0	--	--	--	--

TABLE 17 (continued)

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	9.60	--	9.92	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	--	10.34	--	--
Red at Rustad + Sheyenne at + Buffalo at at Dilworth + Maple at Mapleton	--	--	--	--	--	--	--	--	--	--	19.14

NOTE: No allowance is made for minimum in-stream flow requirements. Year 1980 demands. Values reflect difference between demand and 7-day low streamflow.

TABLE 18

Summary of Additional Storage Needed for Water Supply - Year 1980

	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
50-Yr. Recurr. Int. (ac-ft)	905	1,790	885	805	800	795	705	635	620	625	790
100-Yr. Recurr. Int. (ac-ft)	955	2,330	960	860	850	845	780	690	680	675	880
Ratio 100-Yr: 50-Yr.	1.06	1.30	1.08	1.07	1.06	1.06	1.11	1.07	1.10	1.08	1.11

NOTE: Storage needed for minimum in-stream flows not included.
Year 1980 demands.

Table 19 summarizes the flow shortages from Tables 16 and 17. Alternatives 4-6 and 8-10 have the least shortage, 11.1 cfs. The most extensive regional case, alternative 11, has a shortage of 18.8 cfs. The remaining cases all have shortages of approximately 13 cfs.

Minimum in-stream flow requirements for the Red and Sheyenne Rivers are reflected in Table 20, which lists additional storage needed for in-stream flows (apart from storage for water supply). In most cases, storage between 275 and 400 acre-feet is required. The notable exception is alternative 11, which requires approximately 1,300 acre-feet. A greater storage is needed because in this alternative all demands are placed only on the smaller water supplies available at the upstream boundary of the study area.

Table 21 gives the flow shortages due to in-stream requirements, based on 7-day low flows. In four alternatives, 1-3 and 7, the Sheyenne River has approximately 2 cfs of river flow remaining after meeting water supply needs. Thus, the flow shortages due to in-stream requirements are about 8 cfs for these alternatives. All remaining alternatives include the entire 10-cfs minimum flow in their flow shortages.

Tables 22 and 23 summarize the results of the supply/demand comparisons for year 1980 demands and existing reservoir and diversion operation. In terms of storage volumes (Table 22), the total additional needs generally range from 1,000-1,200

TABLE 19

Summary of Demand Reductions or Additional Flows Needed
for Water Supply - Year 1980

	Supply/Demand Alternative			
	1-3	4-6 & 8-10	7	11
50-Year Recurrence Interval (cfs)	13.3	11.1	12.8	18.8
100-Year Recurrence Interval (cfs)	13.7	11.6	13.3	19.1
Ratio 100-Year:50-Year	1.03	1.05	1.04	1.01

NOTE: No allowance is made for minimum in-stream flow requirements.
Year 1980 demands.

TABLE 20

Additional Storage (acre-feet) Needed to Meet Minimum In-Stream Flows - Year 1980

Supply Point	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Sheyenne at West Fargo	14* (16)**	14 (16)	14 (16)	--	--	--	--	--	--	--	--
Red at Fargo	260 (310)	210 (210)	260 (300)	--	--	--	260 (300)	--	--	--	--
Red at Fargo + Sheyenne at West Fargo	--	--	--	390 (390)	--	400 (430)	--	--	--	--	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	--	--	--	--	370 (380)	--	--	--	--	--	--
Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	22 (26)	--	--	--	--
Red at Fargo + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	390 (430)	--	400 (460)	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	--	--	--	420 (440)	--	--
Red at Rustad + Sheyenne at + Buffalo at at Dilworth + Maple at Mapleton	--	--	--	--	--	--	--	--	--	--	1,310 (1,520)
50-Year R.I. Totals	274	224	274	390	370	400	282	390	420	400	1,310
100-Yr R.I. Totals	326	226	316	390	380	430	326	430	440	460	1,520

*50-year recurrence interval drought
**100-year recurrence interval drought

NOTE: Storage needed for water supply not included but indirectly reflected. Year 1980 demands.

TABLE 21

Demand Reductions or Additional Flows (cfs) Needed to Meet Minimum In-Stream Flows - Year 1980

Supply Point	Supply/Demand Alternative 1-3	4 & 6	5	7	8 & 10	9	11
Sheyenne at West Fargo	.8* (.9)**	--	--	--	--	--	--
Red at Fargo	7.0 (7.0)	--	--	7.0 (7.0)	--	--	--
Red at Fargo + Sheyenne at West Fargo	--	10.0 (10.0)	--	--	--	--	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo	--	--	10.0 (10.0)	--	--	--	--
Sheyenne at West Fargo + Maple at Mapleton	--	--	--	1.2 (1.3)	--	--	--
Red at Fargo + Sheyenne West Fargo + Maple at Mapleton	--	--	--	--	10.0 (10.0)	--	--
Red at Fargo + Buffalo at Dilworth + Sheyenne at West Fargo + Maple at Mapleton	--	--	--	--	--	10.0 (10.0)	--
Red at Rustad + Sheyenne at Horace + Buffalo at Dilworth + Maple at Mapleton	--	--	--	--	--	--	10.0 (10.0)
50-Yr. Recurr. Int. Totals	7.8	10.0	10.0	8.2	10.0	10.0	10.0
100-Yr. Recur. Int. Totals	7.9	10.0	10.0	8.3	10.0	10.0	10.0
Ratio 100-Yr: 50-Yr.	1.01	1	1	1.08	1	1	1

*50-year recurrence interval drought
**100-year recurrence interval drought

NOTE: Year 1980 demands. Values reflect difference between demand and 7-day low streamflow.

TABLE 22

Summary of Total Additional Storage Needs - Year 1980

Water Need	Supply/Demand Alternative										
	1	2	3	4	5	6	7	8	9	10	11
Water Supply (ac-ft)	* 905 **(955)	1,790 (2,330)	885 (960)	805 (860)	800 (850)	795 (845)	705 (780)	635 (690)	620 (680)	625 (675)	790 (880)
In-Stream Flow (ac-ft)	* 275 **(325)	225 (225)	275 (315)	390 (390)	370 (380)	400 (430)	280 (325)	390 (430)	420 (440)	400 (460)	1,310 (1,520)
50-Yr R.I. Totals (ac-ft)	1,180	2,015	1,160	1,195	1,170	1,195	985	1,025	1,040	1,025	2,100
100-Yr R.I. Totals (ac-ft)	1,280	2,555	1,275	1,250	1,230	1,275	1,105	1,120	1,120	1,135	2,400
Ratio 100-Yr: 50-Yr	1.08	1.27	1.10	1.05	1.05	1.07	1.12	1.09	1.03	1.11	1.14

*50-year recurrence interval drought
**100-year recurrence interval drought

NOTE: Year 1980 demands.

TABLE 23

Summary of Total Demand Reduction or Additional Flow Needs - Year 1980

	Supply/Demand Alternative			
	1-3	4-6 & 8-10	7	11
Water Supply (cfs)	13.3* (13.7)**	11.1 (11.6)	12.8 (13.3)	18.8 (19.1)
In-Stream Flow (cfs)	7.8* (7.9)**	10.0 (10.0)	8.2 (8.3)	10.0 (10.0)
50-Year Recurrence Interval (cfs)	21.1	21.1	21.0	28.8
100-Year Recurrence Interval (cfs)	21.6	21.6	21.6	29.1
Ratio 100-Year:50-Year	1.02	1.02	1.03	1.01

*50-year recurrence interval drought
**100-year recurrence interval drought

NOTE: Year 1980 demands.

acre-feet, with in-stream flow requirements accounting for 20-40 percent. Storage needs for the 100-year recurrence interval are generally within 10 percent of the 50-year needs. Exceptions to the above are alternatives 2 and 11, which have storage needs twice as great as the others and other differences.

In terms of flow rate (Table 23), alternatives 1-10 have the same total flow shortage, approximately 21 cfs. The regional alternative 11 has nearly twice as large a shortage. Minimum in-stream flow requirements account for 8-10 cfs in all cases. There is little difference between the 50-year and 100-year recurrence interval flow shortages.

Conclusions and Recommendation

Study area water demands for both 2030 and 1980 are predicted to exceed available surface water supplies, based on a 50-year recurrence interval drought. For the best alternative supply schemes, the total additional storage required to balance supplies and demands is in the range of 2,000 to 2,500 acre-feet for the year 2030 case and 1,000 to 1,200 acre-feet for 1980. The minimum in-stream flow requirements for the Red and Sheyenne Rivers account for large portions of the total storage needs -- generally 55 to 60 percent for the year 2030 and 20 to 40 percent for the year 1980 case.

Flow rate comparisons, based on 7-day low streamflows and average demands, show total shortages of 32 cfs for the best schemes in the 2030 case and 21 cfs for the best schemes in 1980. These

totals include fully 10 cfs for in-stream flow requirements in the 2030 case and 8 to 10 cfs for these requirements in the 1980 case. Flow shortages and additional storage volumes for a 100-year recurrence interval drought are generally within 10 percent of the 50-year results.

In all, 11 alternative supply/demand schemes are evaluated. Two of the alternatives yield much greater total storage needs and flow shortages than the other nine, which give generally similar results. Typical of the latter are the alternative 1 results depicted in Figures 89 and 90.

For 1980, large storages needed on the South Branch Buffalo River at Sabin dominate many of the alternatives studied. It should be noted that the demands accounted for here are mostly agricultural. Irrigation plus livestock demands exceed 11 cfs during July-September. Groundwater supplies meet most of these demands at present. Therefore, the 1980 study area water shortages developed here on the basis of 100-percent surface water use do not reflect present conditions. Also, though the urban areas are the focus of this study, rural (i.e., agricultural) water use is a major factor necessarily considered.

The 1980 water shortages on the Red and Sheyenne Rivers are somewhat overestimated because of the small inconsistency between demands used in the HEC-3 model analysis (performed in 1976-77) and the actual 1980 demands used in the present study. The HEC-3

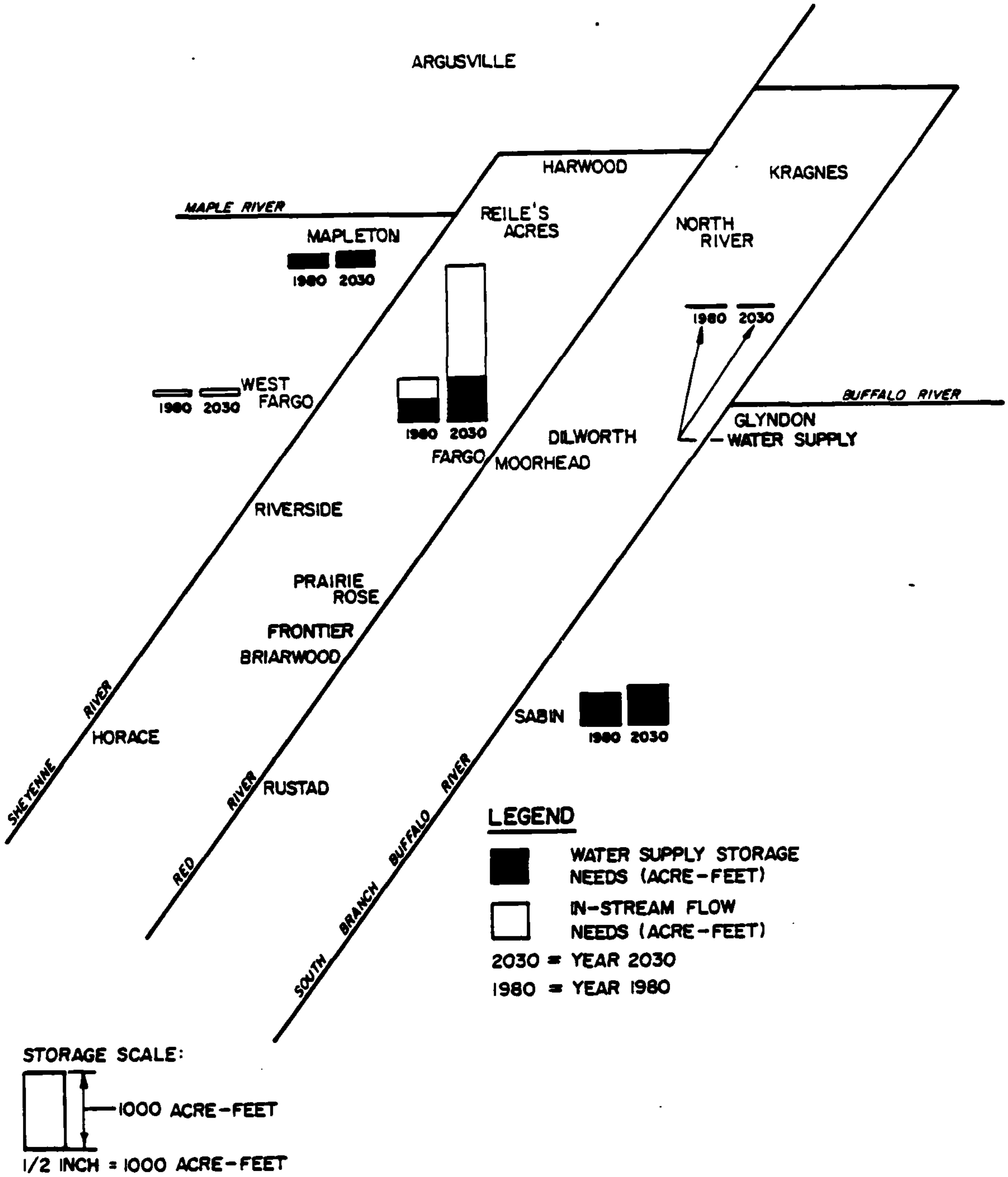


FIGURE 89: Comparison of Typical Year 2030 and Year 1980 Additional Storage Needs, Assuming Surface Water Supply Only (Alternative 1 - 50-Year Recurrence Interval)

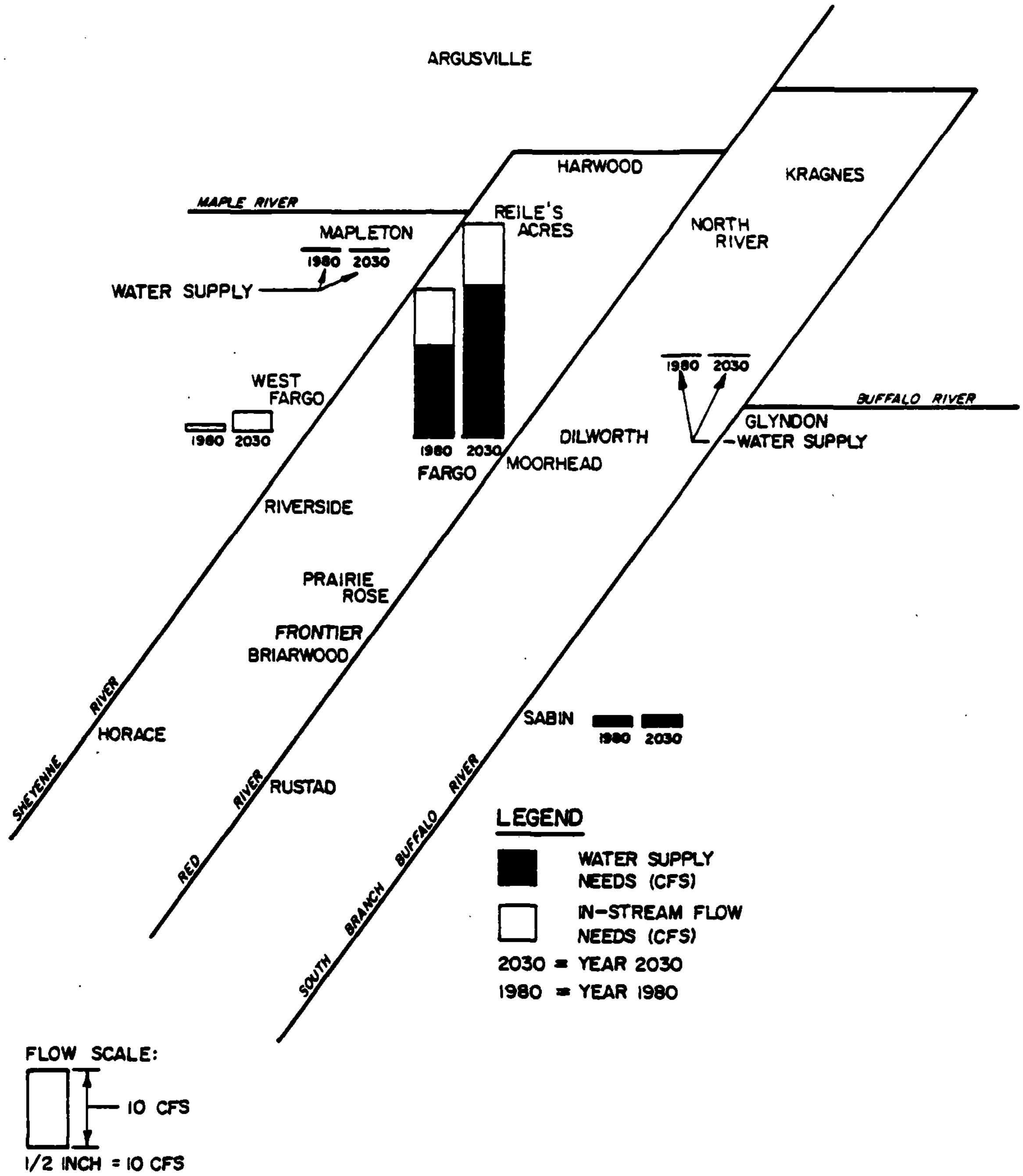


FIGURE 90: Comparison of Typical Year 2030 and Year 1980 Demand Reduction or Additional Flow Needs, Assuming Surface Water Supply Only (Alternative 1 - 50-Year Recurrence Interval)

analysis reflects study area demands totaling 27 cfs. The resulting streamflow records were used in the present study, but here actual demands totaling approximately 29 cfs were imposed. The operation of upstream reservoirs feeding the Red and Sheyenne Rivers is tied to study area demands in the HEC-3 analysis. Consequently, modeled streamflows at times are insufficient for the actual demands imposed. But it is apparent that the reservoirs would be capable of releasing more water if the actual demands were used in the HEC-3 model.

The evidence for the above conclusion is in the low-flow frequency curves for the Sheyenne River at West Fargo and the Red River at Fargo. (See Figures 4 and 9 for the year 2030 case and Figures 48 and 52 for 1980.) As previously discussed, the low flows of shorter duration and longer recurrence interval (lower right portion of the figures) are generally higher for the 2030 case than for 1980 at these supply points. This reflects reservoir releases during extreme drought periods which are larger in the year 2030 case, to meet the larger projected demands. This supports the conclusion that the reservoirs could release more water for the 1980 case if the HEC-3 model were consistent with actual 1980 demands.

Despite probable overestimation of water shortages for the year 1980 case, total reliance on surface waters in the Fargo-Moorhead study area would carry a real danger of water shortages. An indication of this is the finding that study area flow shortages are comparable to or greater than present (1980) groundwater use.

Flow shortages based on 7-day, 50-year low streamflows total at least 11 cfs for water supply only and at least 21 cfs considering minimum in-stream flows. (See Table 23.) Average annual groundwater use in the study area is roughly 10 cfs at present.

In light of the conclusions above, it is recommended that careful investigation and regional planning of water supply in the study area be completed. The present broad-view, three-phase study has this as its aim.

V. REFERENCES

1. U.S. Army Corps of Engineers, St. Paul District, "Water Supply/Conservation Investigations for the Fargo-Moorhead Urban Study Area, North Dakota and Minnesota - Phase 1, Part 1: Water Demand Projections," March 1982.

2. Chow, Ven Te, "Runoff," in Ven Te Chow, ed, Handbook of Applied Hydrology, McGraw-Hill, 1964.

3. Stall, J.B., "Reservoir Mass Analysis by a Low Flow Series," Proceedings American Society of Engineers, Journal Sanitary Engineering Division, v. 88, September 1962.

4. Stall, J.B. and J.C. Neill, "Calculated Risks of Impounding Reservoir Yield," Proceedings American Society of Civil Engineers, Journal Hydraulics Division, v. 89, January 1963.

5. Hardison, C. and Riggs, H., "Storage Analysis for Water Supply," U.S. Geological Survey, Book 4, Chapter B2, Techniques of Water Resources Investigation, 1973.

6. Klemes, V., "Storage-Mass-Curve Analysis in a Systems-Analytic Perspective," Water Resources Research, Vol. 15, April 1979.

7. U.S. Army Corps of Engineers, Hydrologic Engineering Center, "HEC-3, Reservoir System Analysis for Conservation," Program Number 723-X6-L2030, July 1974.

8. U.S. Army Corps of Engineers, Hydrologic Engineering Center, "HEC-4, Monthly Stream Flow Simulation," Program Number 723-X6-L2340, February 1971.

9. Beard, Leo R., Statistical Methods in Hydrology, U.S. Army Corps of Engineers, January 1962.

10. U.S. Army Corps of Engineers, Hydrologic Engineering Center, "Partial Duration - Independent Low Flow Events," Program Number 723-G1-L2290, July 1966; in U.S. Army Corps of Engineers, Hydrologic Engineering Center, Hydrologic Engineering Methods for Water Resources Development - Volume 8, Reservoir Yield, January 1975.

11. Chow, Ven Te, "Statistical and Probability Analysis of Hydrologic Data," in Ven Te Chow, ed, Handbook of Applied Hydrology, McGraw-Hill, 1964.

12. U.S. Geological Survey, Frequency of Low Flows, Red River of the North, North Dakota - Minneosta, Published by North Dakota State Water Conservation Commission, 1962.

13. State of Kansas, Water Resources Board, Kansas Stream Flow Characteristics, Part 4, Storage Requirements to Sustain Gross Reservoir Outflow, April 1962.

14. U.S. Army Corps of Engineers, St. Paul District, "Stage 3 Low-Flow Frequency Analysis," in Grand Forks-East Grand Forks Urban Water Resources Study, July 1981.

15. Souris-Red-Rainy River Basins Commission, "Souris-Red-Rainy River Basins Comprehensive Study," Vol. 8, Appendix O, pp. 132-133, 1972.

FIGURES 3 - 88

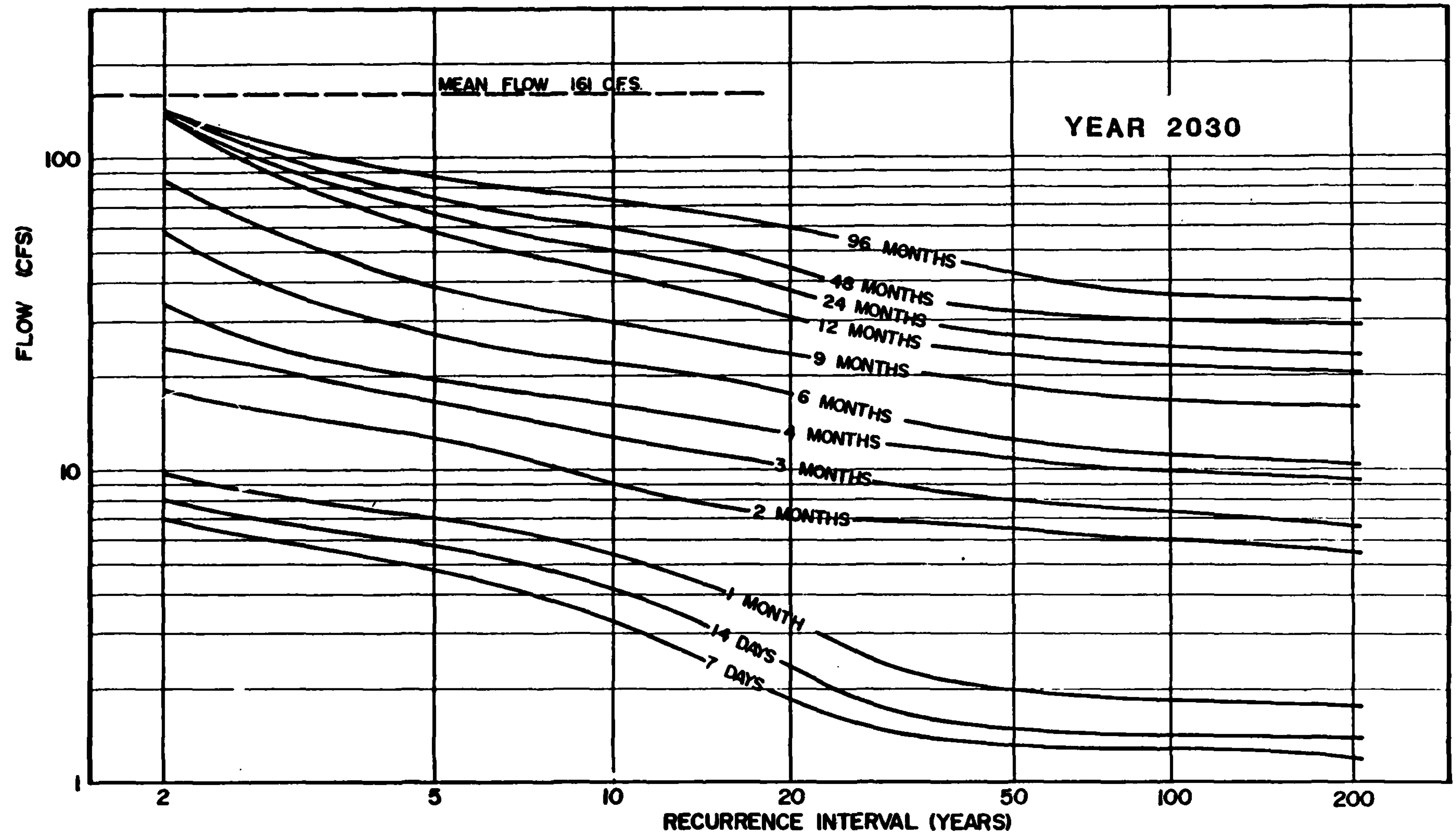


FIGURE 3: Low-Flow Frequency Curves, Sheyenne River at Horace - Year 2030 Case

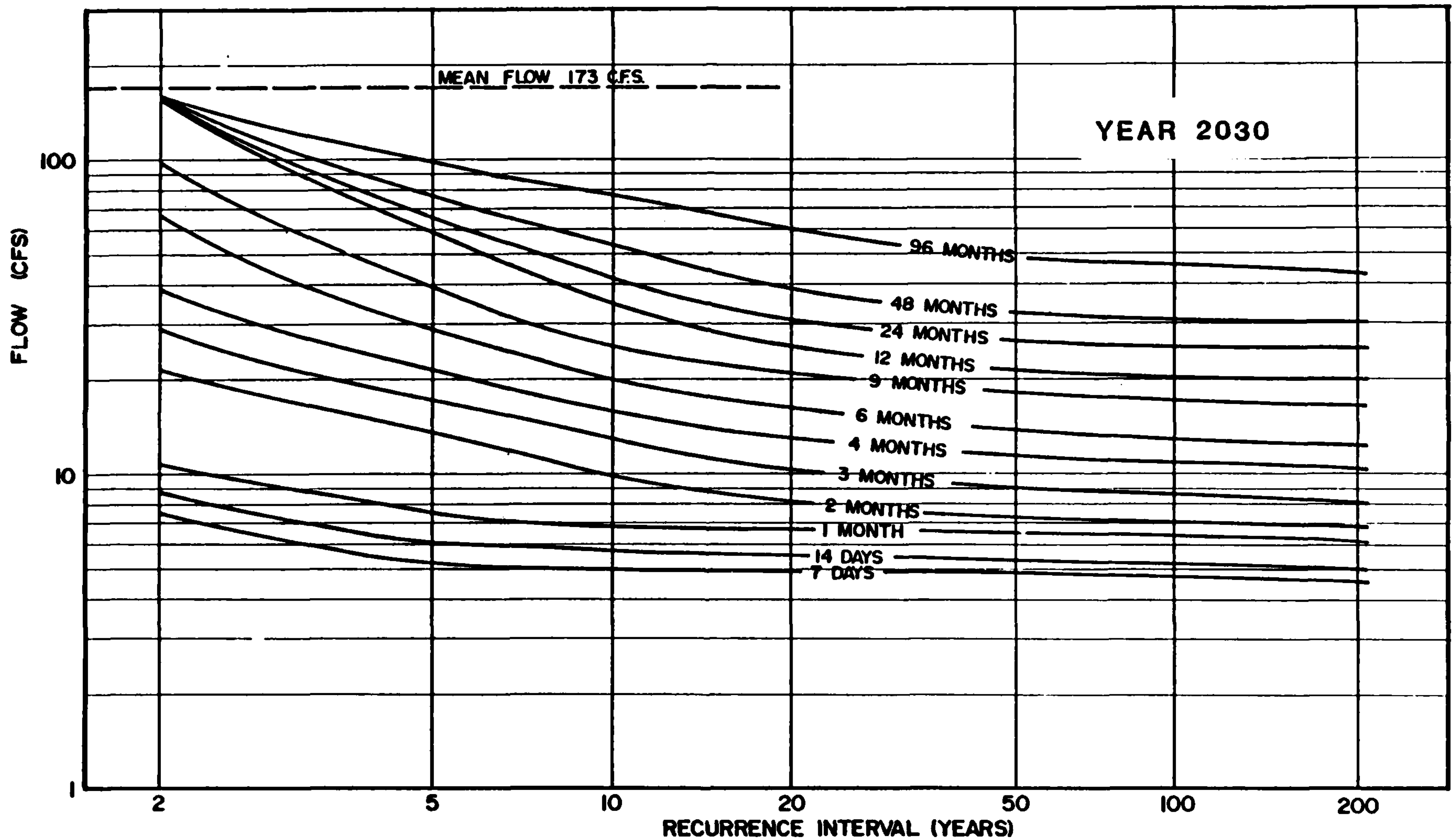


FIGURE 4: Low-Flow Frequency Curves, Sheyenne River at West Fargo - Year 2030 Case

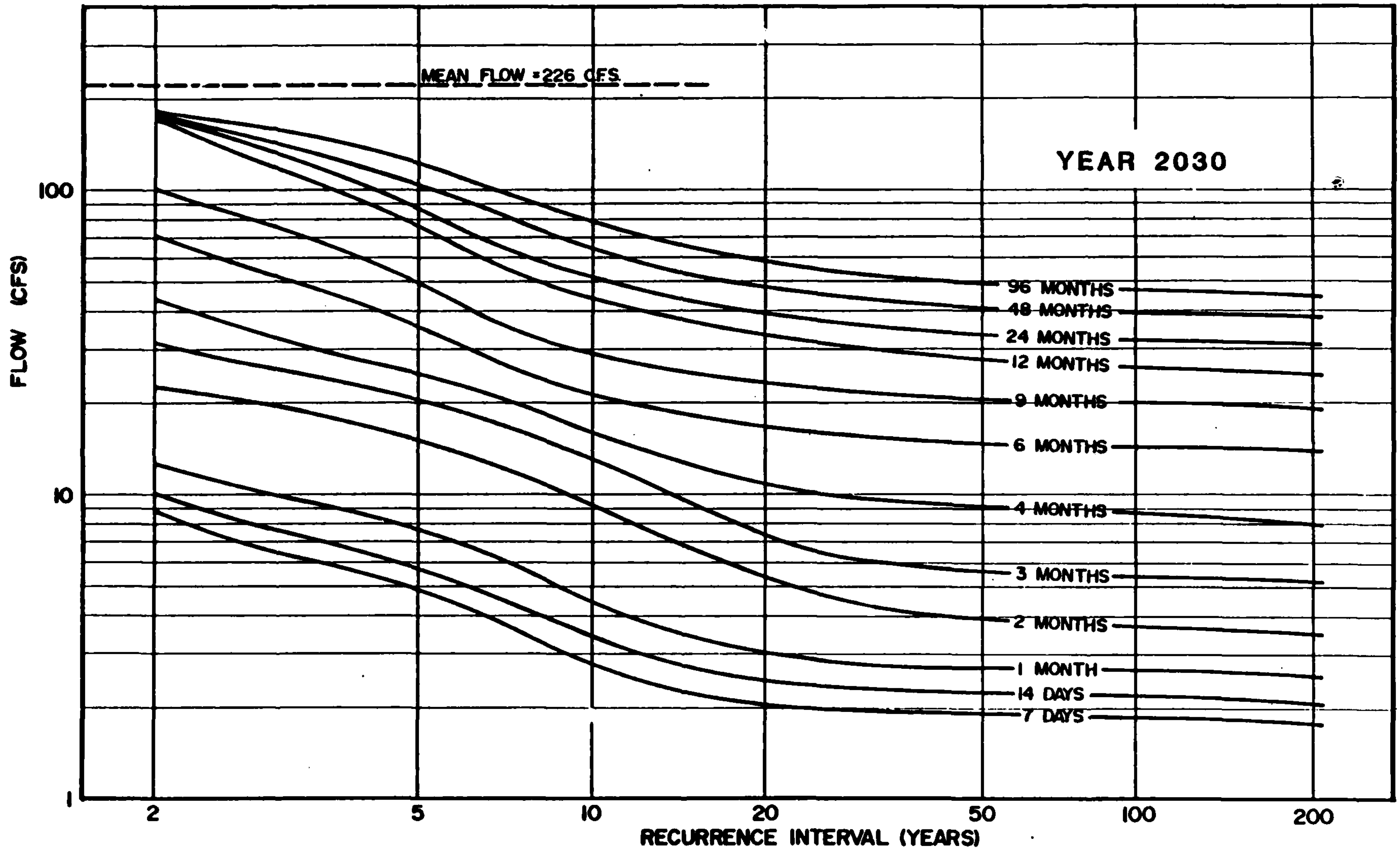


FIGURE 5: Low-Flow Frequency Curves, Sheyenne River at Reile's Acres - Year 2030 Case

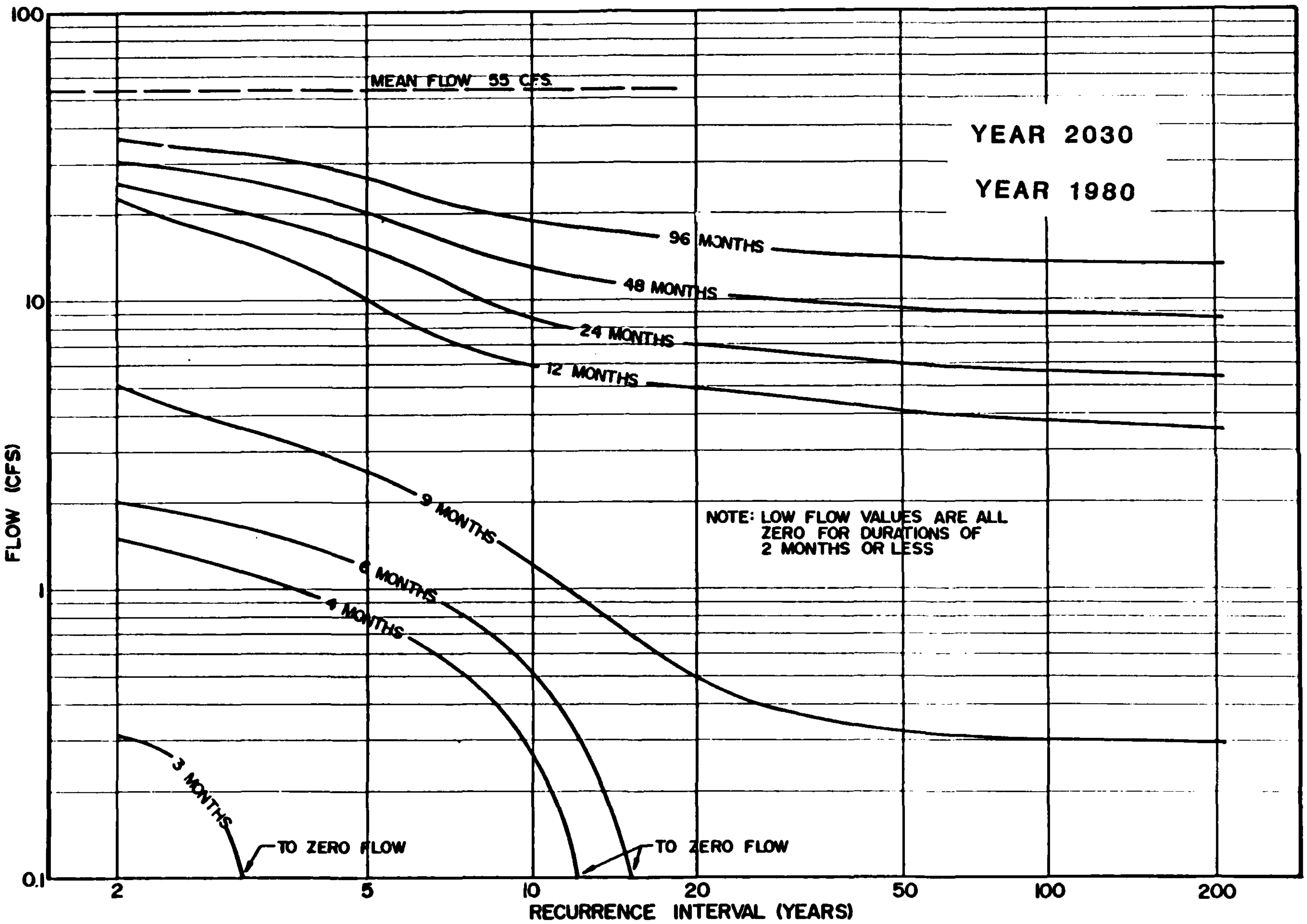


FIGURE 6: Low-Flow Frequency Curves, Maple River at Mapleton - Year 2030 and 1980 Cases

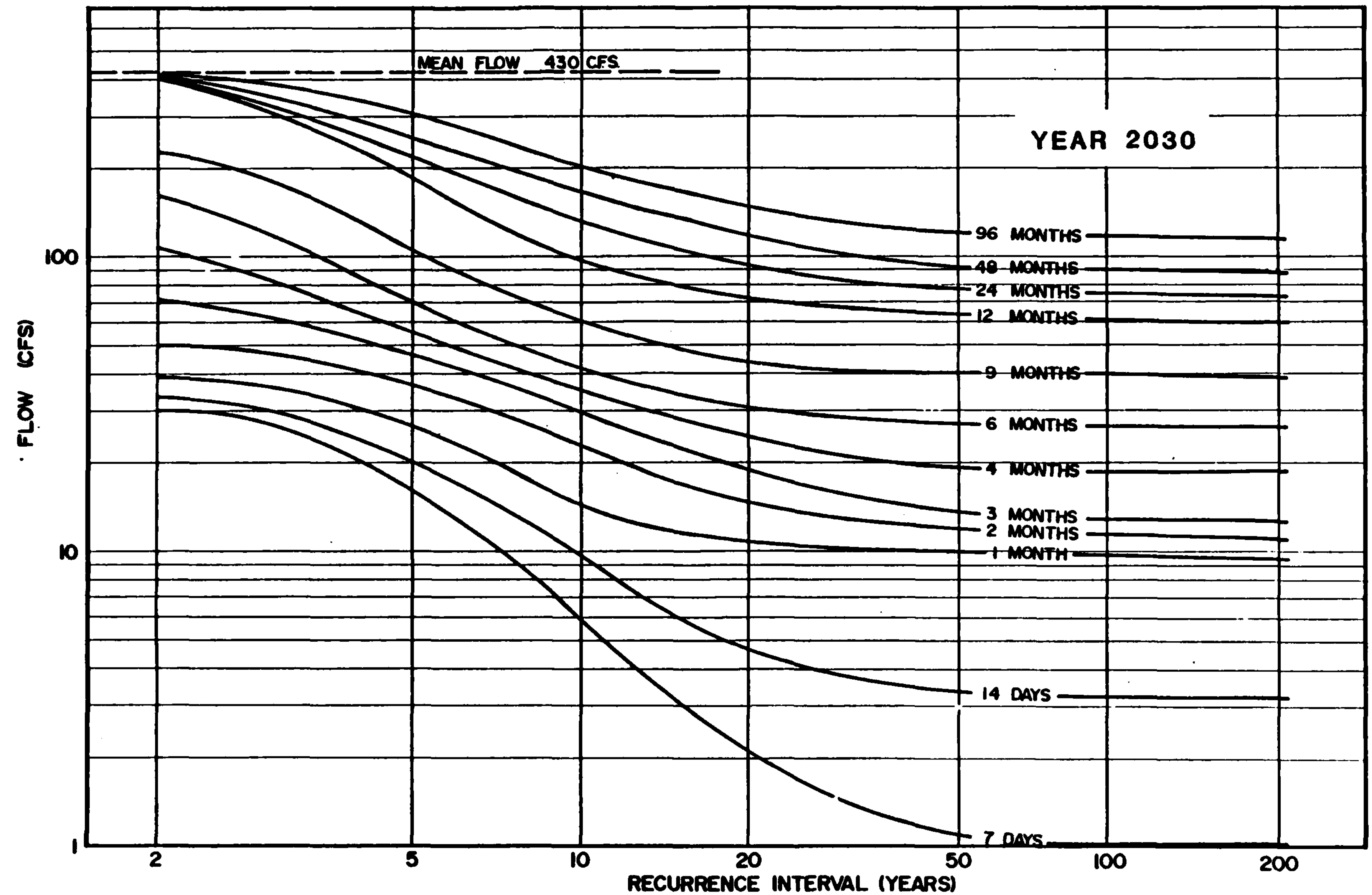


FIGURE 7: Low-Flow Frequency Curves, Red River at Rustad - Year 2030 Case

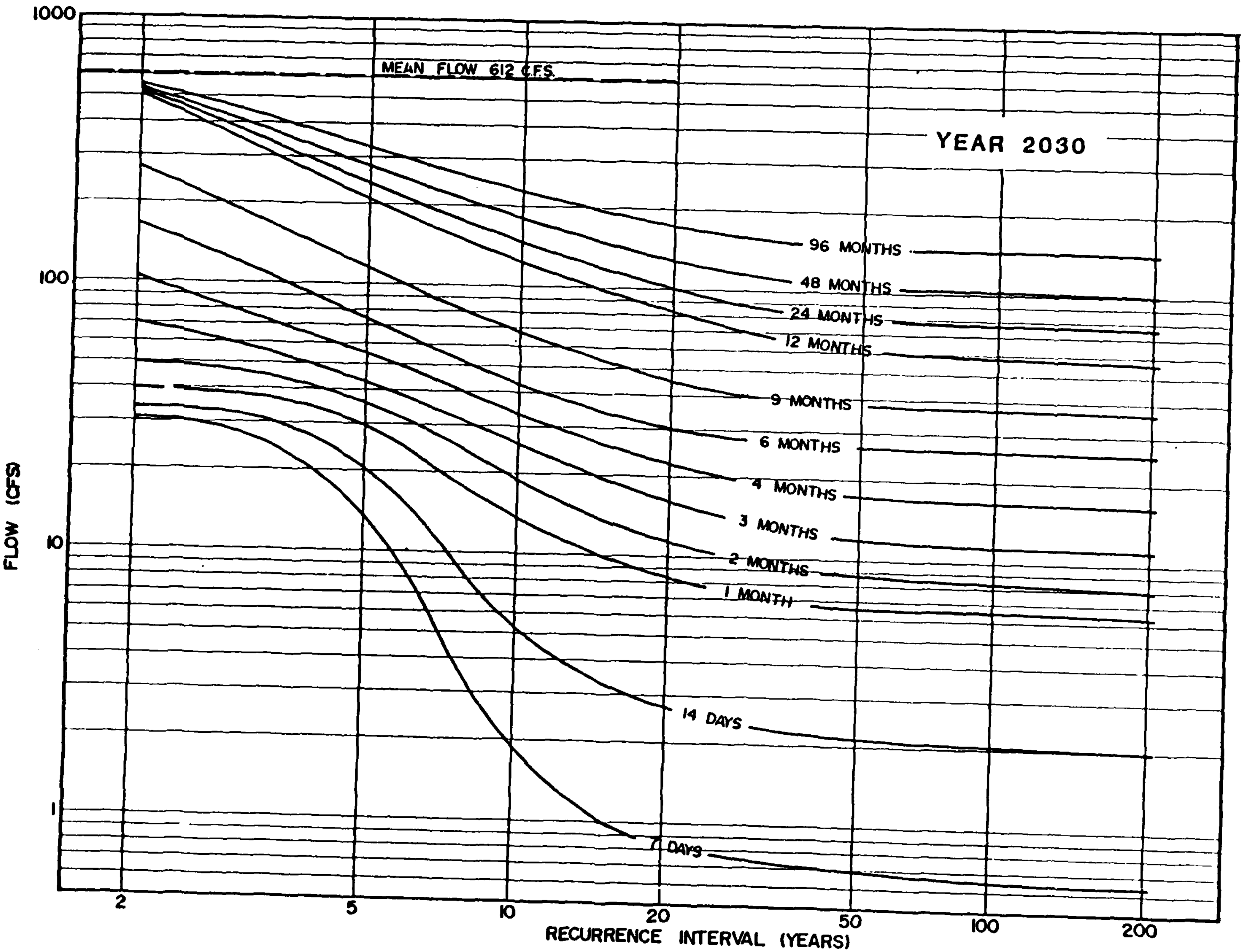


FIGURE 8: Low-Flow Frequency Curves, Red River at Briarwood - Year 2030 Case

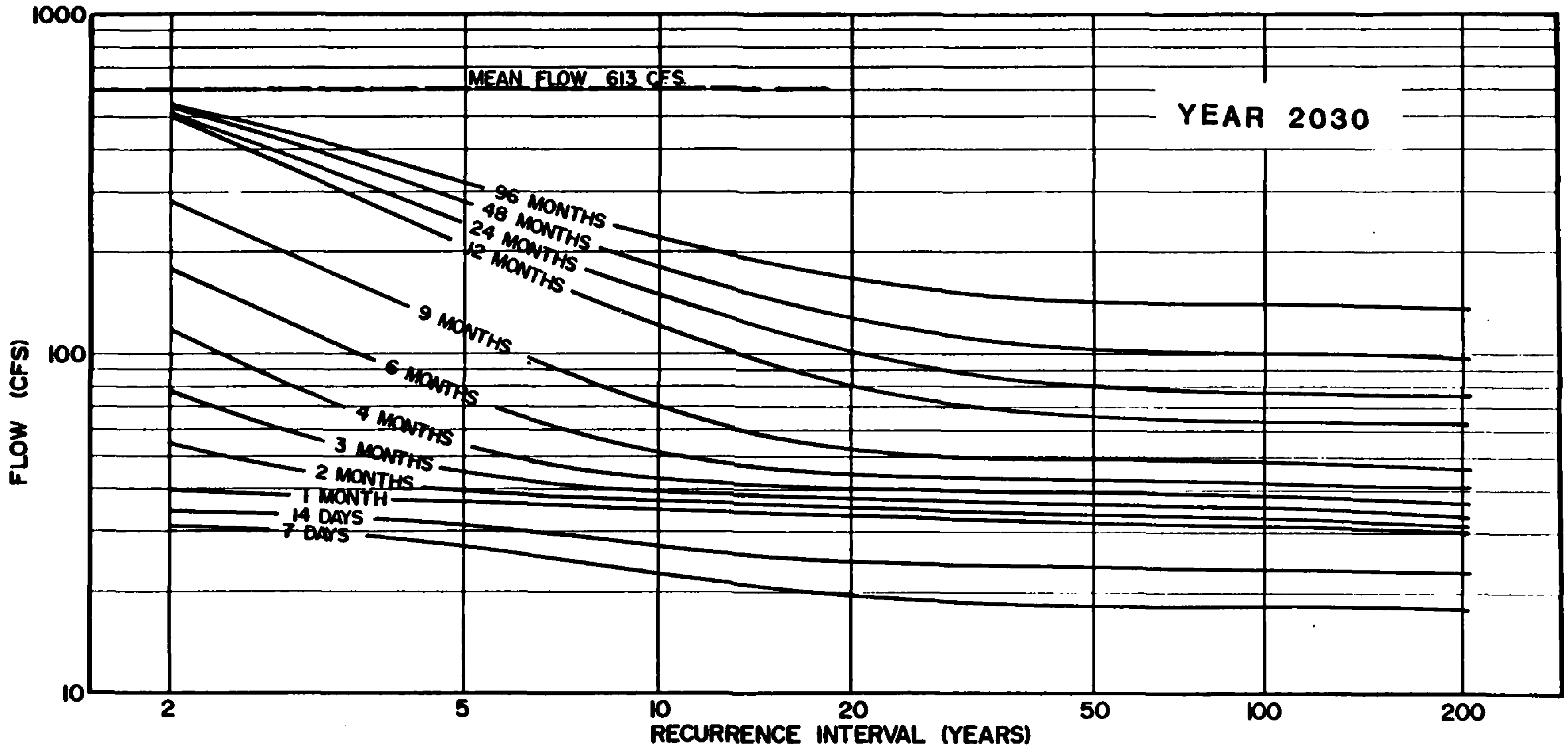


FIGURE 9: Low-Flow Frequency Curves, Red River at Fargo - Year 2030 Case

NOTE: This figure is a graphical presentation of data considering the effect of the Sheyenne diversion. The counterpart to this figure, considering the recently completed Sheyenne pipeline is included in Appendix A.

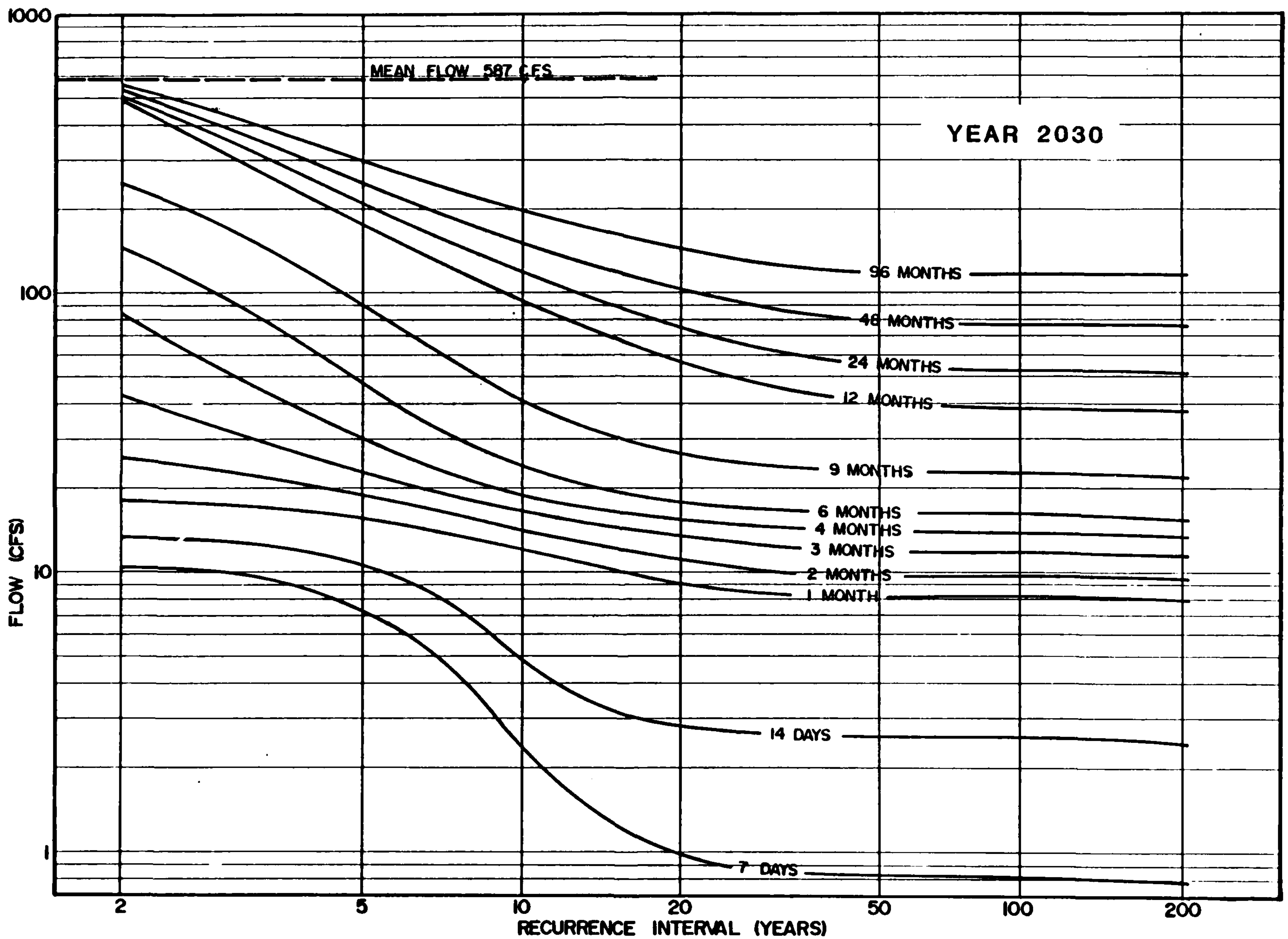


FIGURE 10: Low-Flow Frequency Curves, Red River at North River - Year 2030 Case

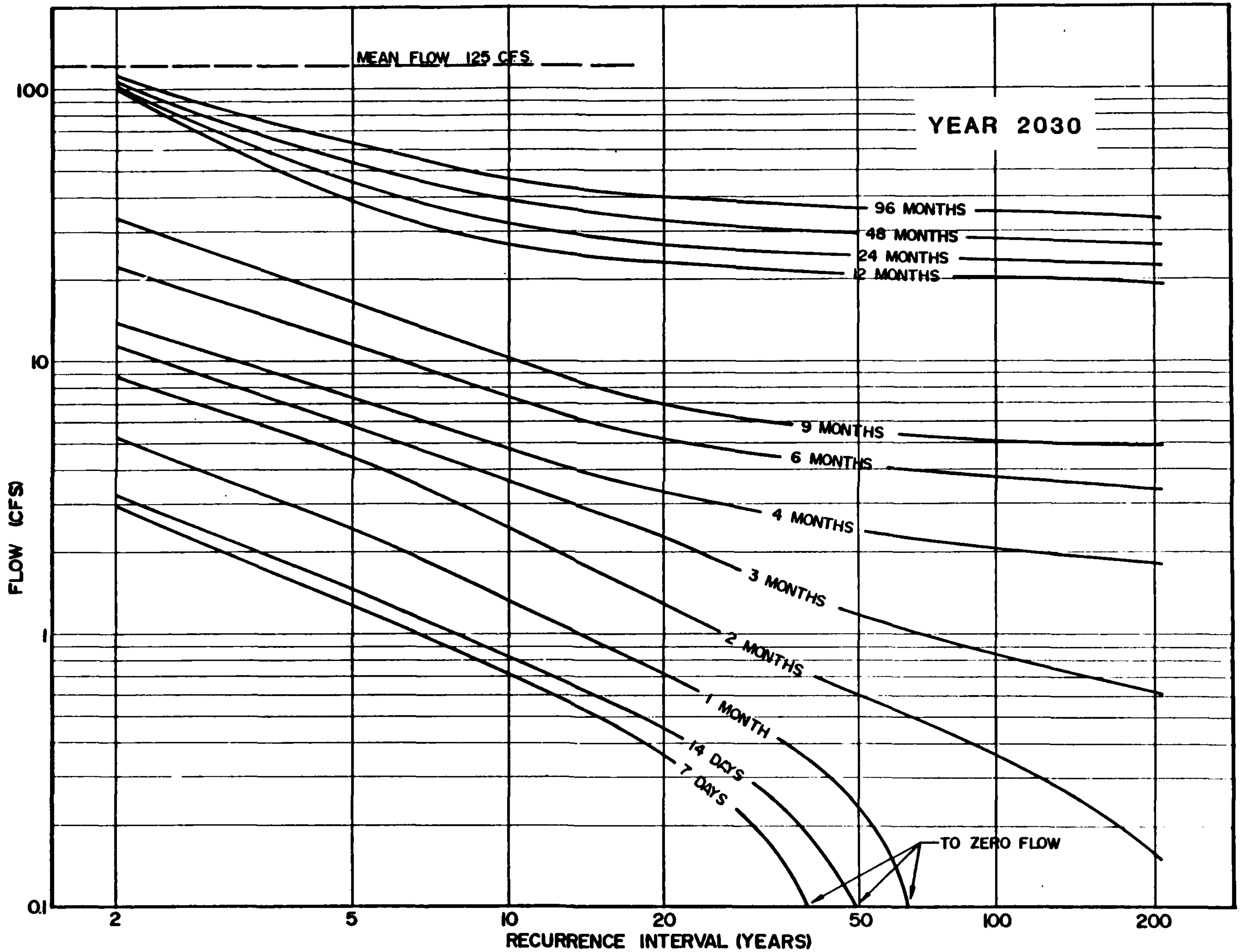


FIGURE 11: Low-Flow Frequency Curves, Buffalo River at Dilworth - Year 2030 Case

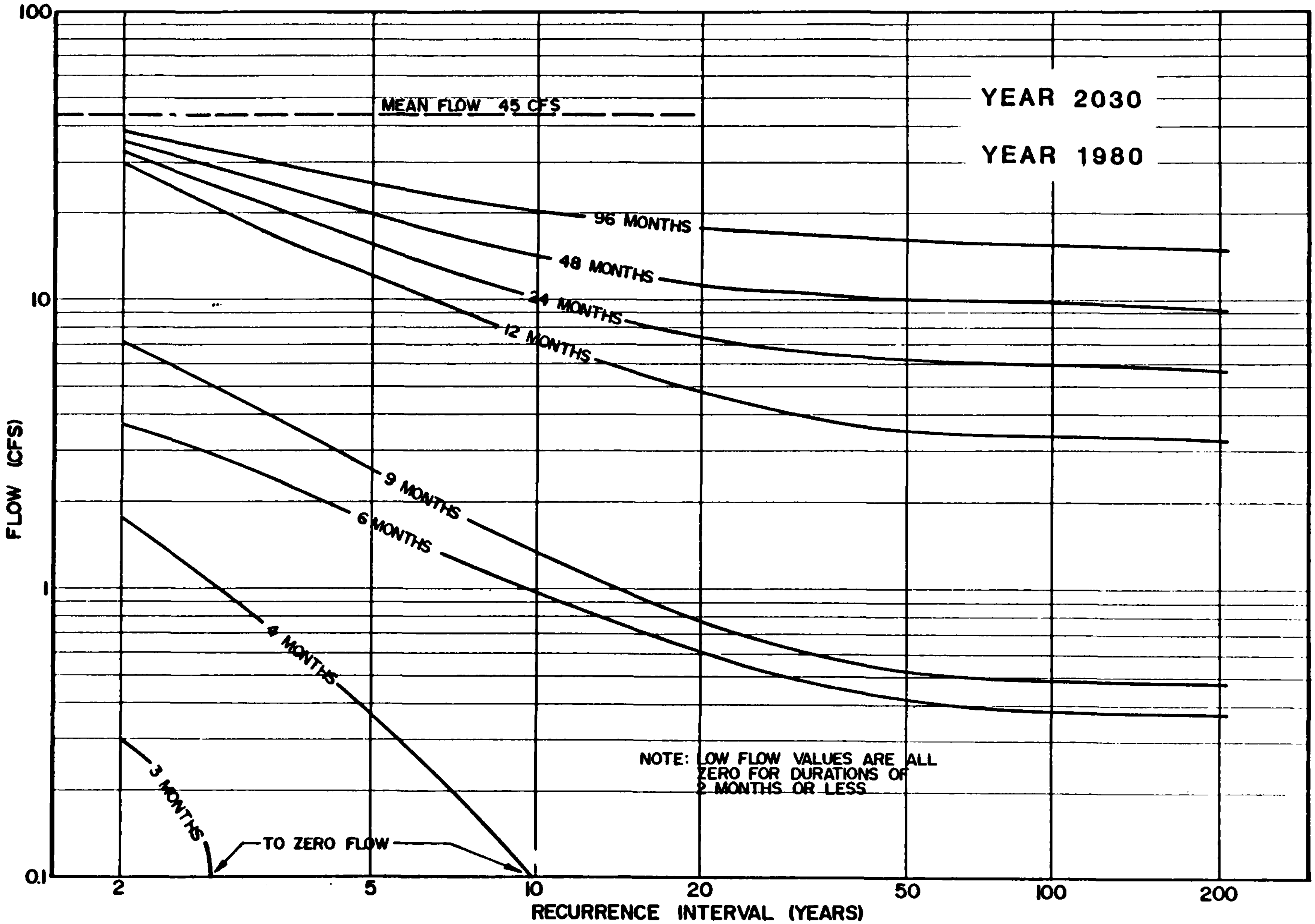


FIGURE 12: Low-Flow Frequency Curves, South Branch Buffalo River at Sabin - Year 2030 and 1980 Cases

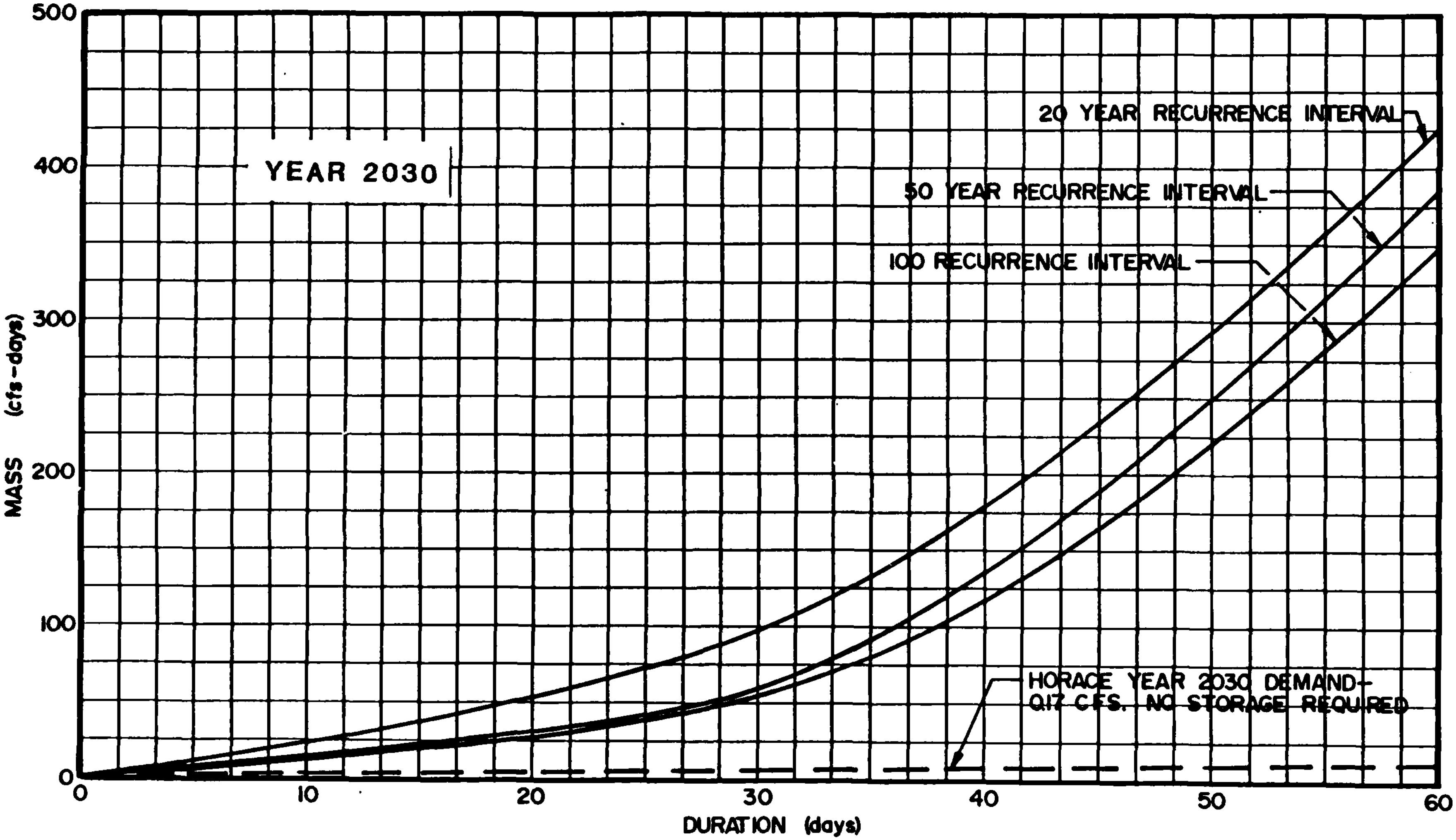


FIGURE 13: Mass Curves for the Sheyenne River at Horace(Alternatives 1-10)

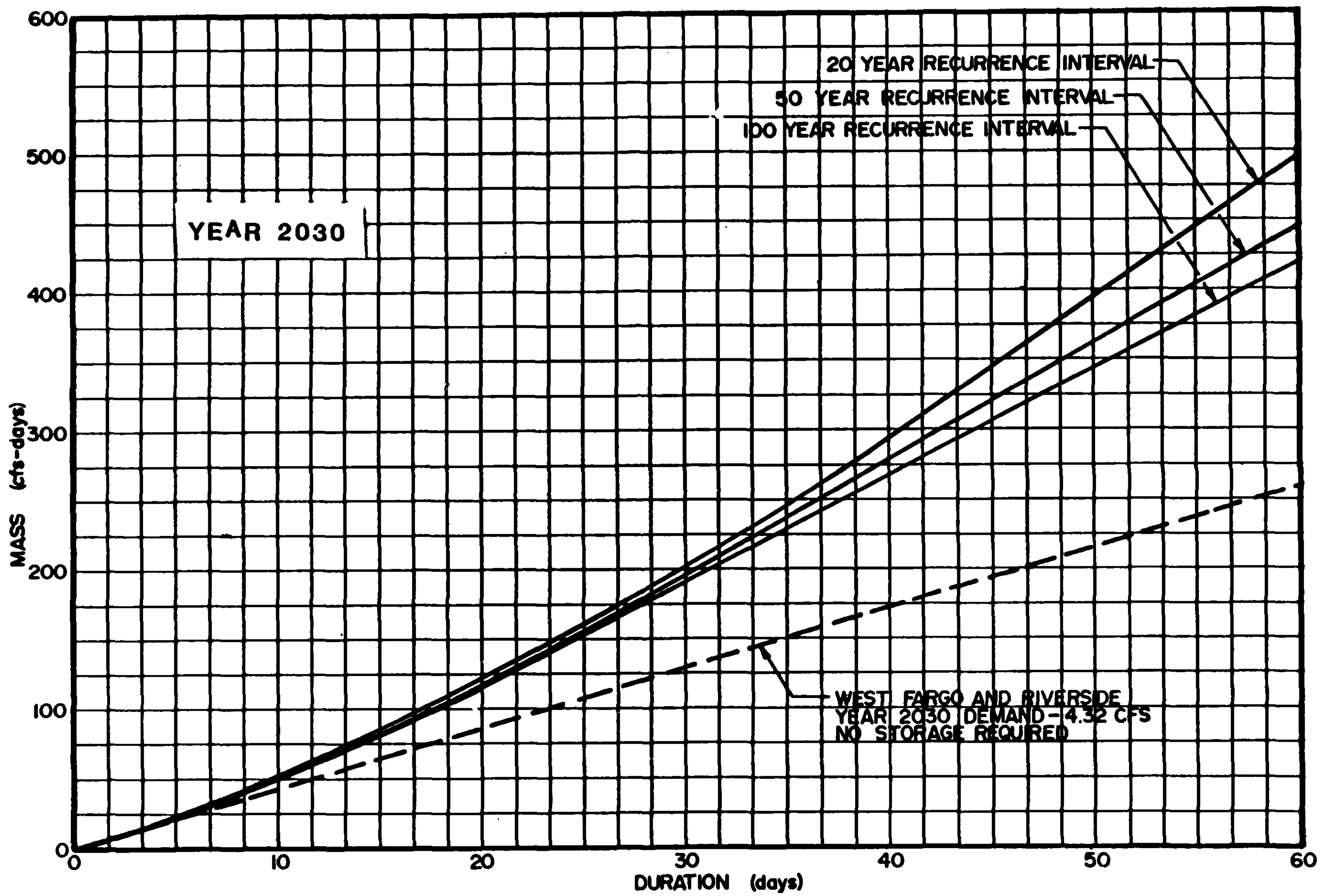


FIGURE 14: Mass Curves for the Sheyenne River at West Fargo (Alternatives 1-3)

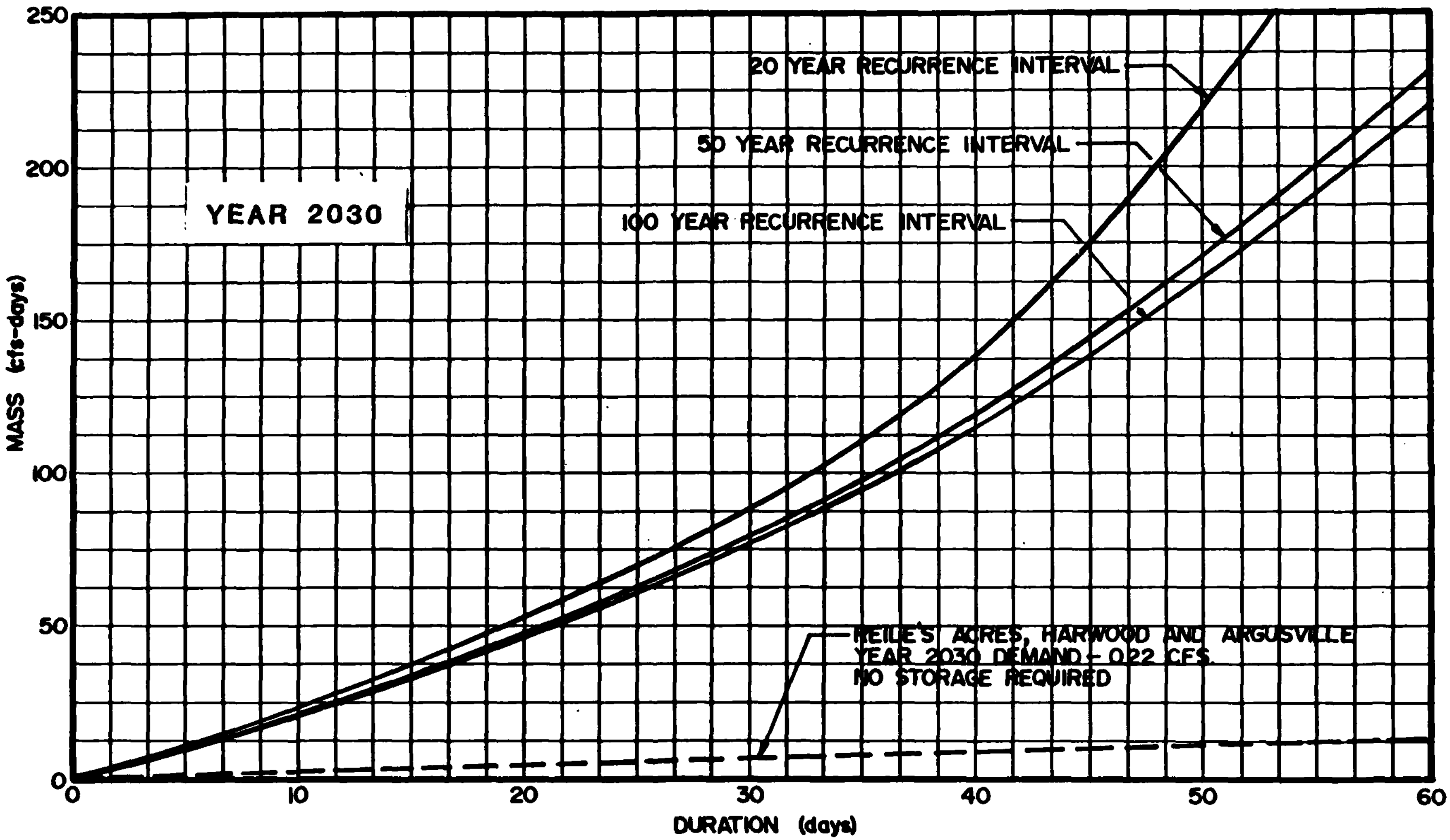


FIGURE 15: Mass Curves for the Sheyenne River at Reile's Acres(Alternatives 1-10)

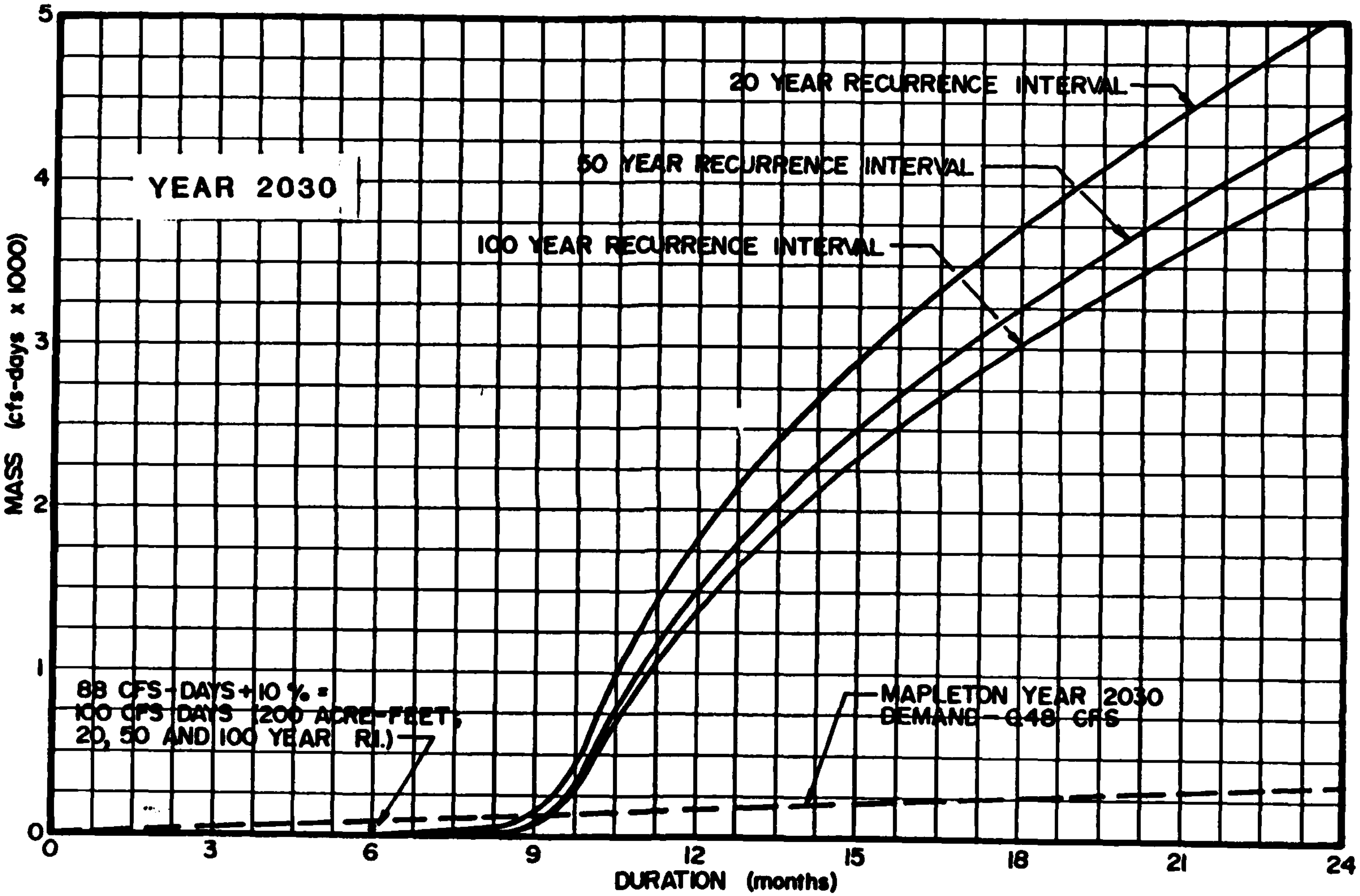


FIGURE 16: Mass Curves for the Maple River at Mapleton (Alternatives 1-6)

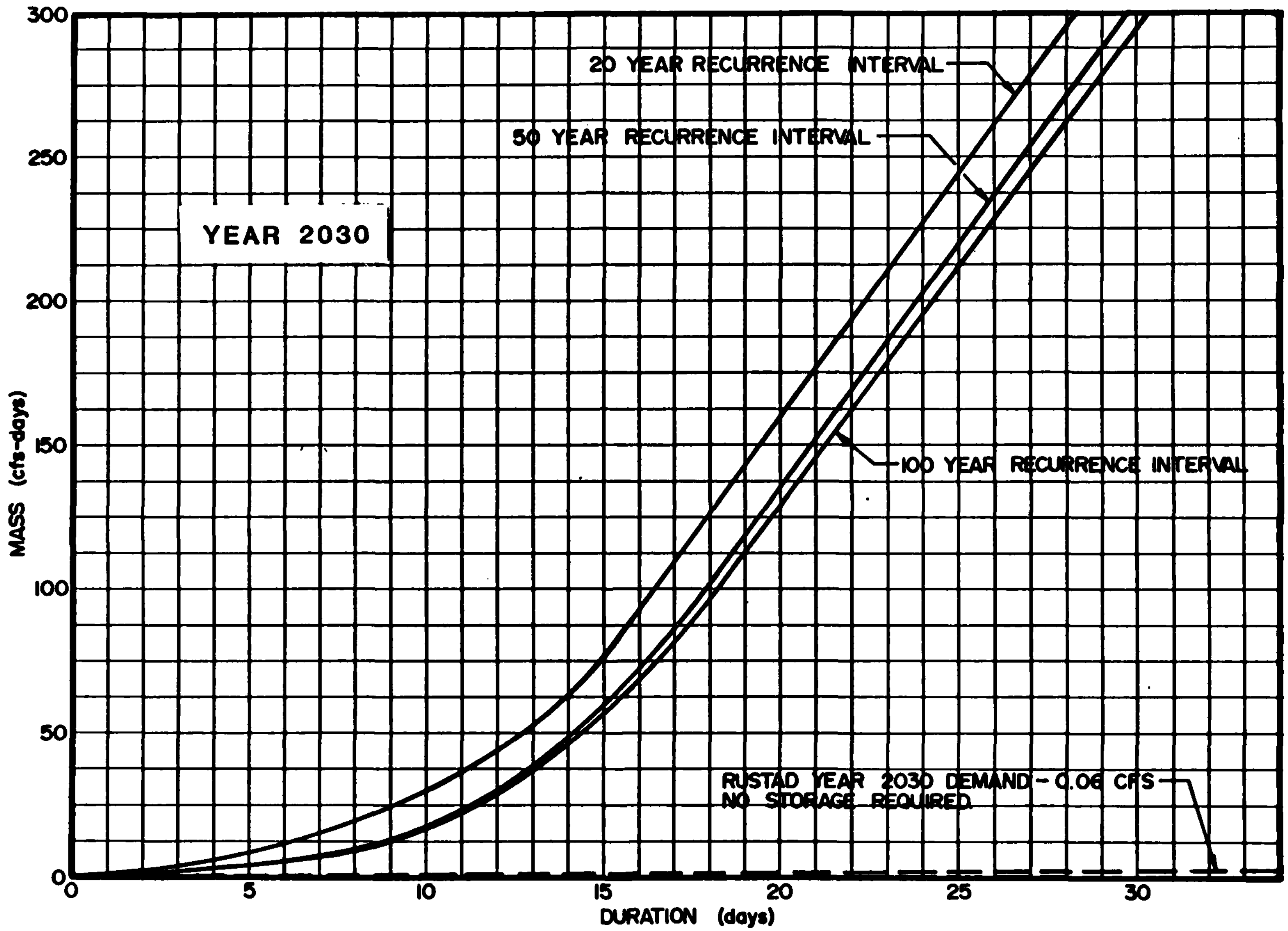


FIGURE 17: Mass Curves for the Red River at Rustad (Alternatives 1-10)

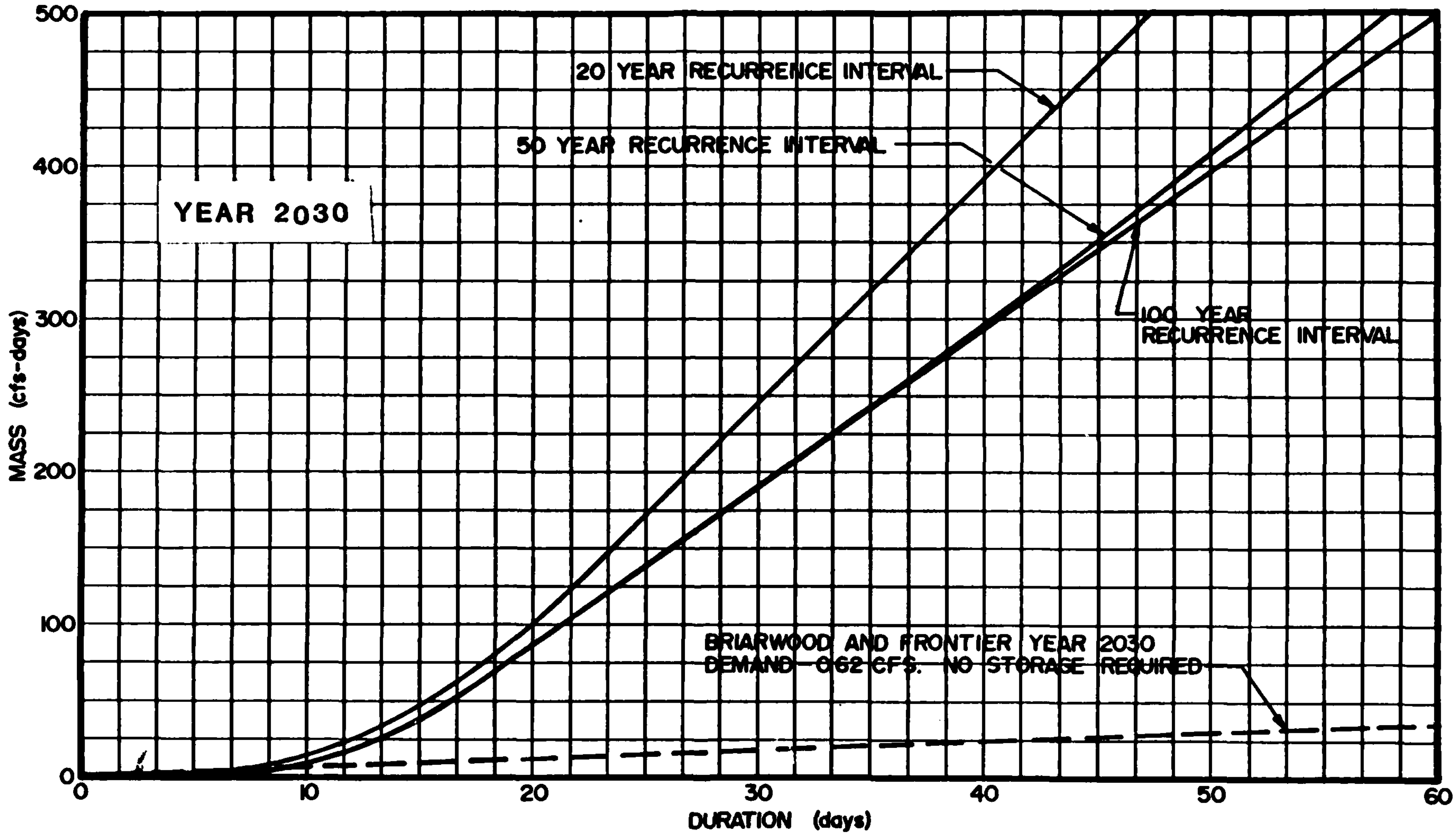


FIGURE 18: Mass Curves for the Red River at Briarwood(Alternatives 1-10)

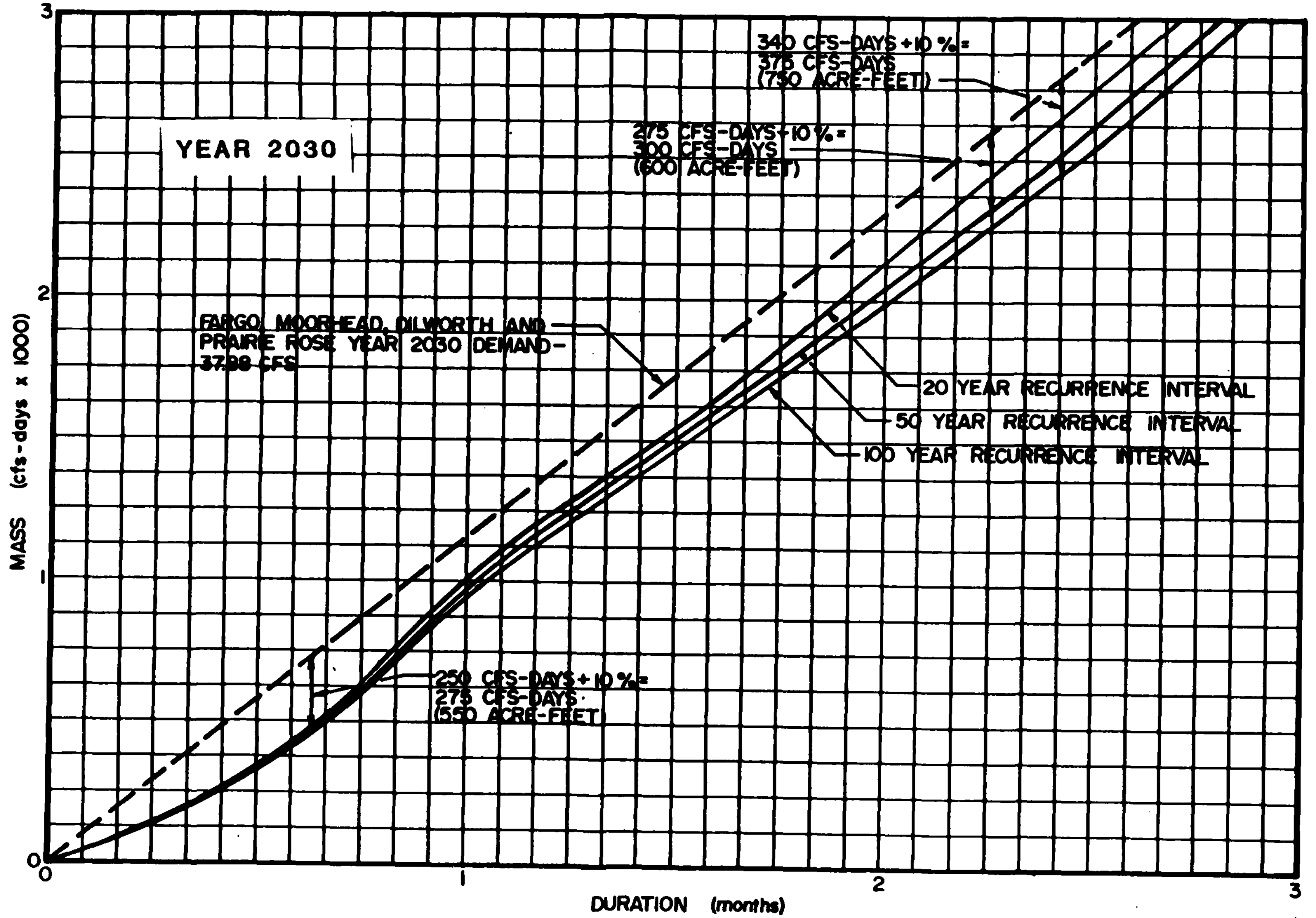


FIGURE 19: Mass Curves for the Red River at Fargo (Alternative 1)

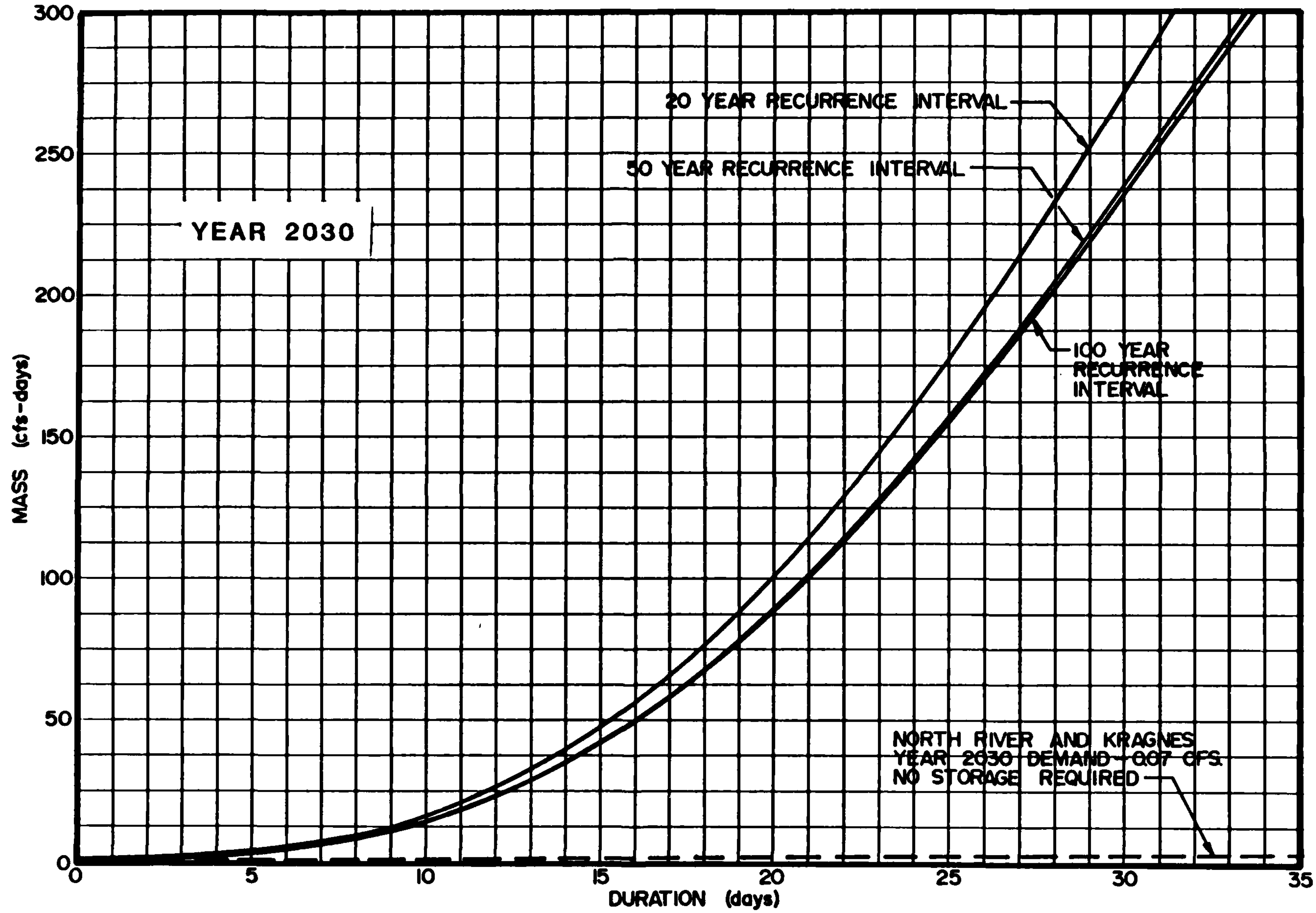


FIGURE 20: Mass Curves for the Red River at North River (Alternatives 1-10)

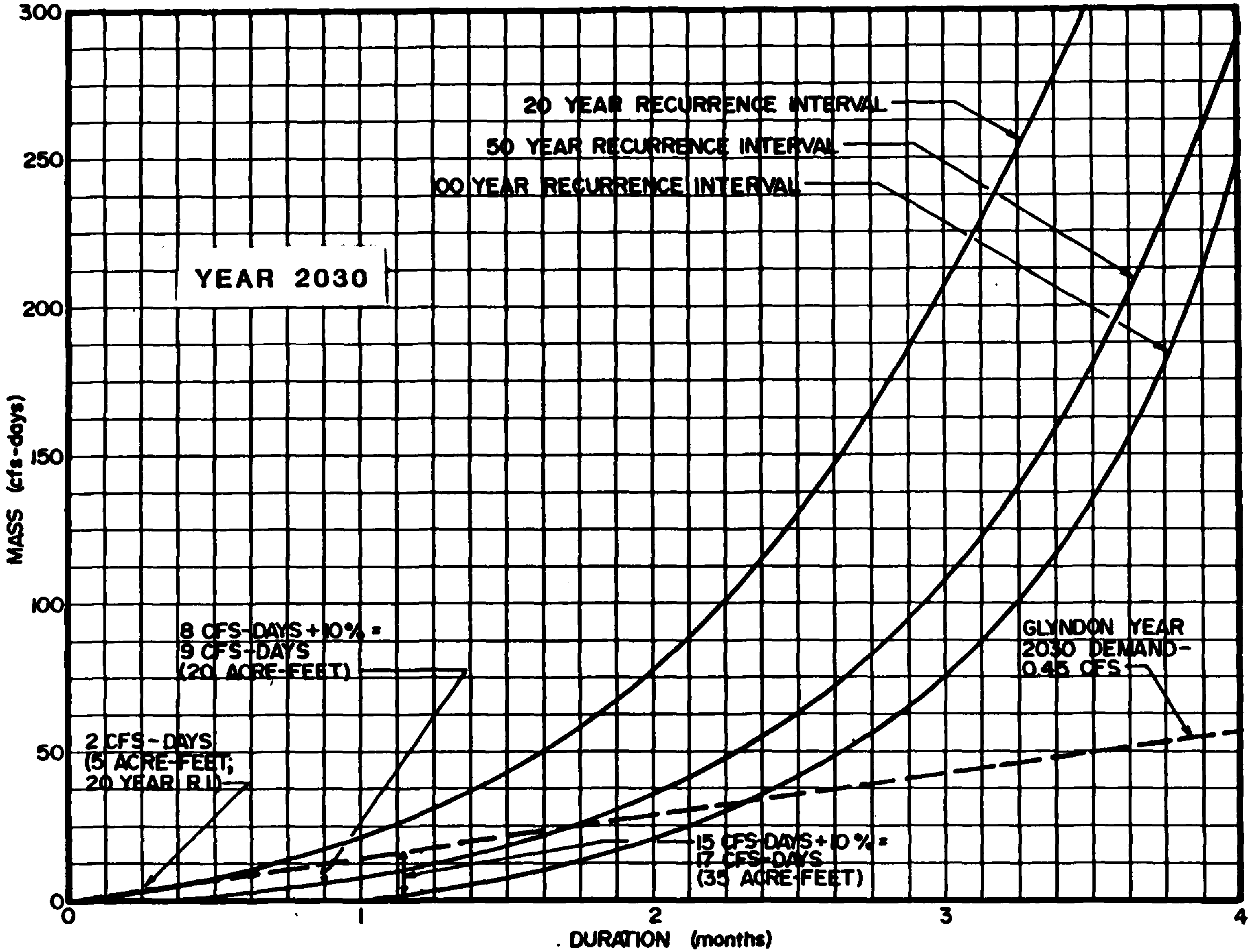


FIGURE 21: Mass Curves for the Buffalo River at Dilworth (Alternatives 1,6,10)

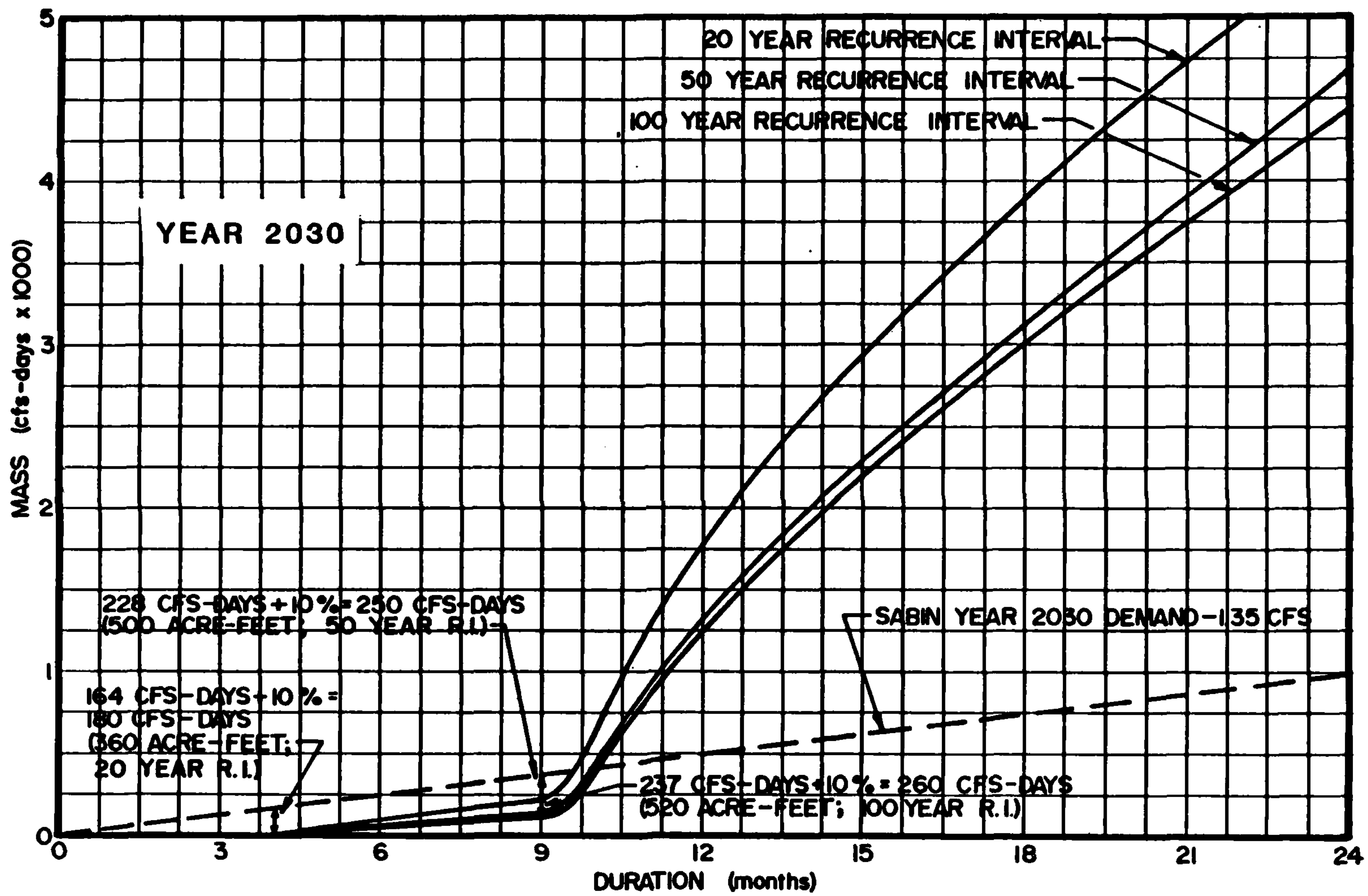


FIGURE 22: Mass Curves for the South Branch Buffalo River at Sabin (Alternatives 1-10)

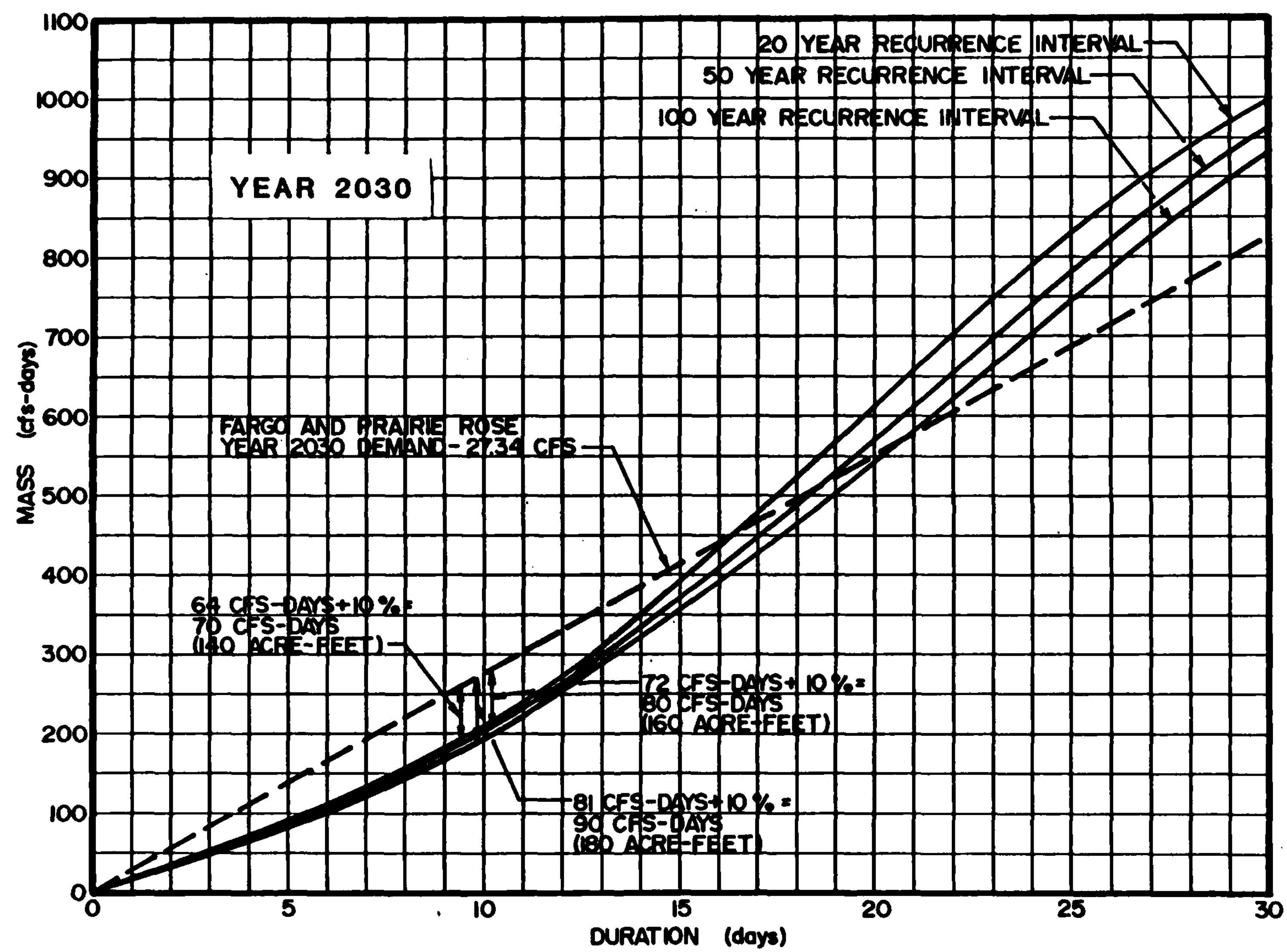


FIGURE 23: Mass Curves for the Red River at Fargo (Alternative 2)

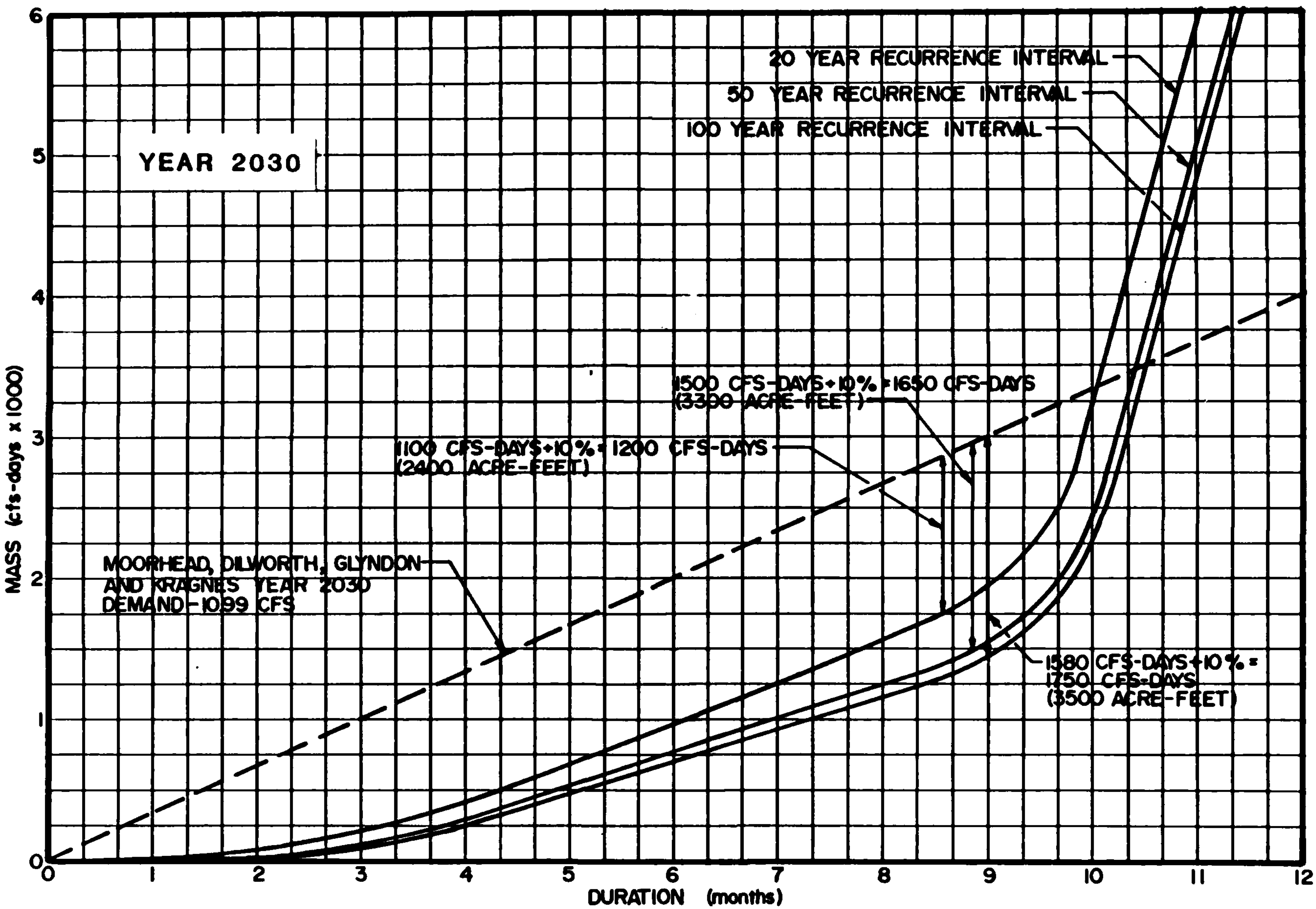


FIGURE 24: Mass Curves for the Buffalo River at Dilworth(Alternative 2)

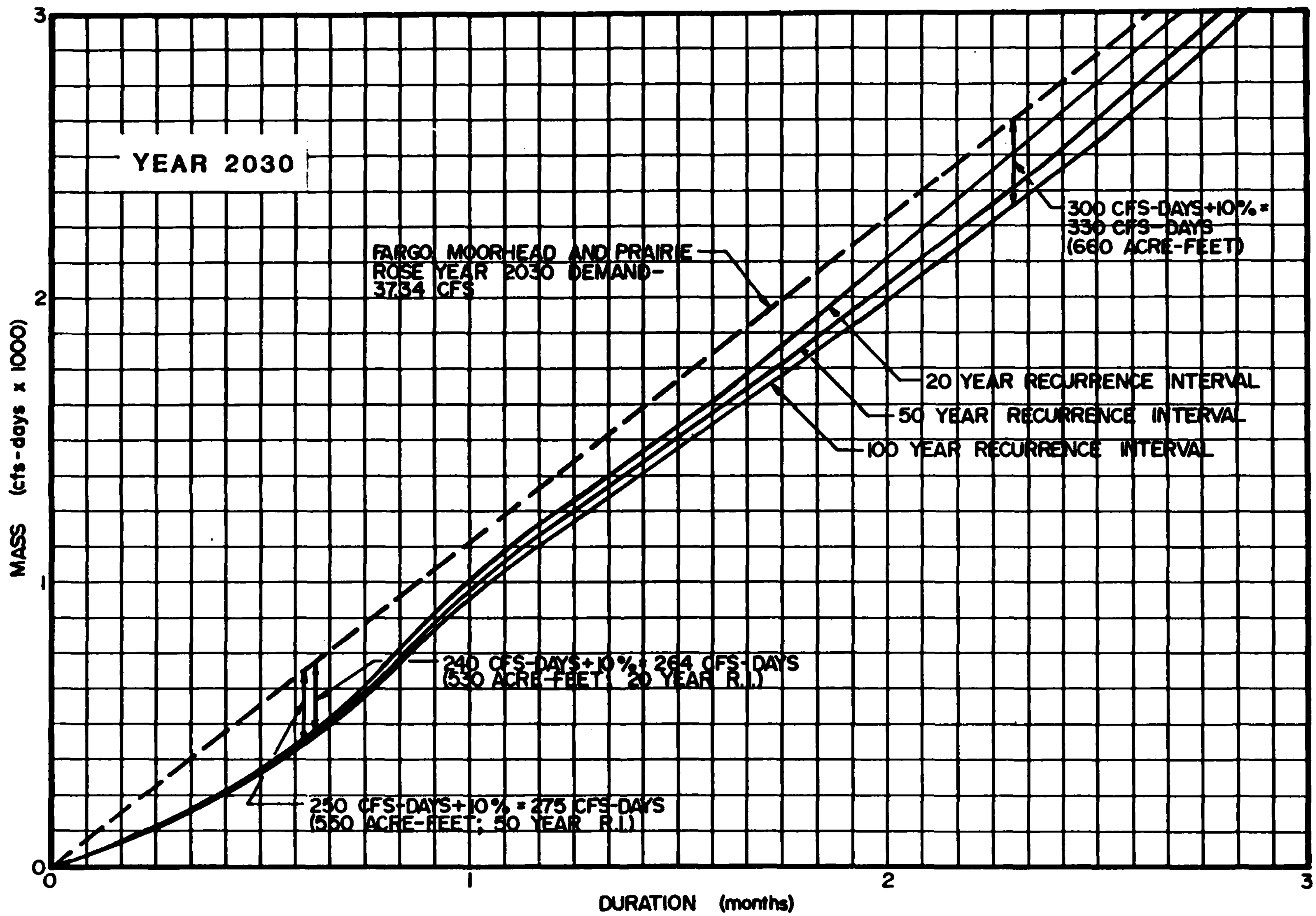


FIGURE 25: Mass Curves for the Red River at Fargo (Alternatives 3 and 7)

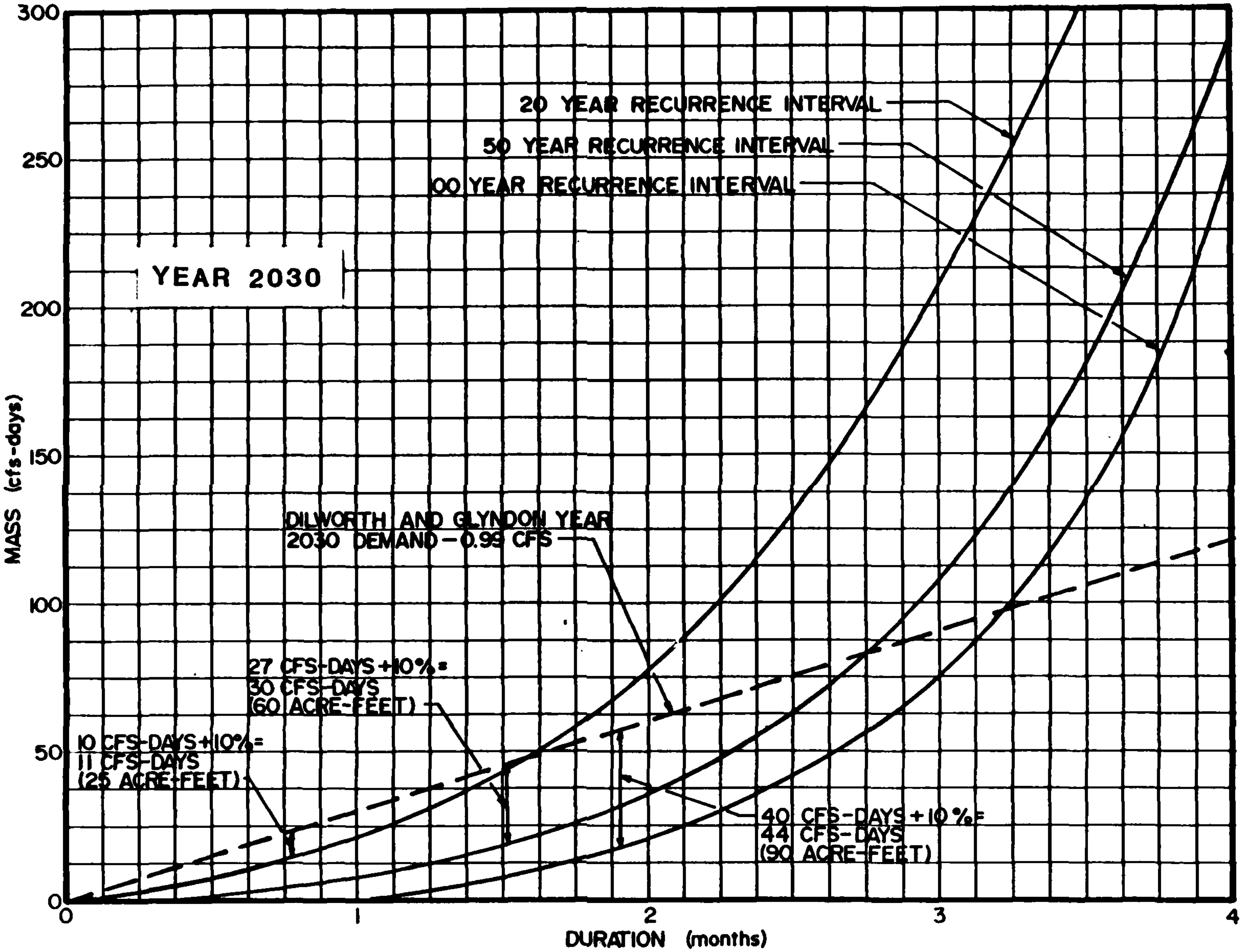


FIGURE 26: Mass Curves for the Buffalo River at Dilworth (Alternatives 3, 4, 7 and 8)

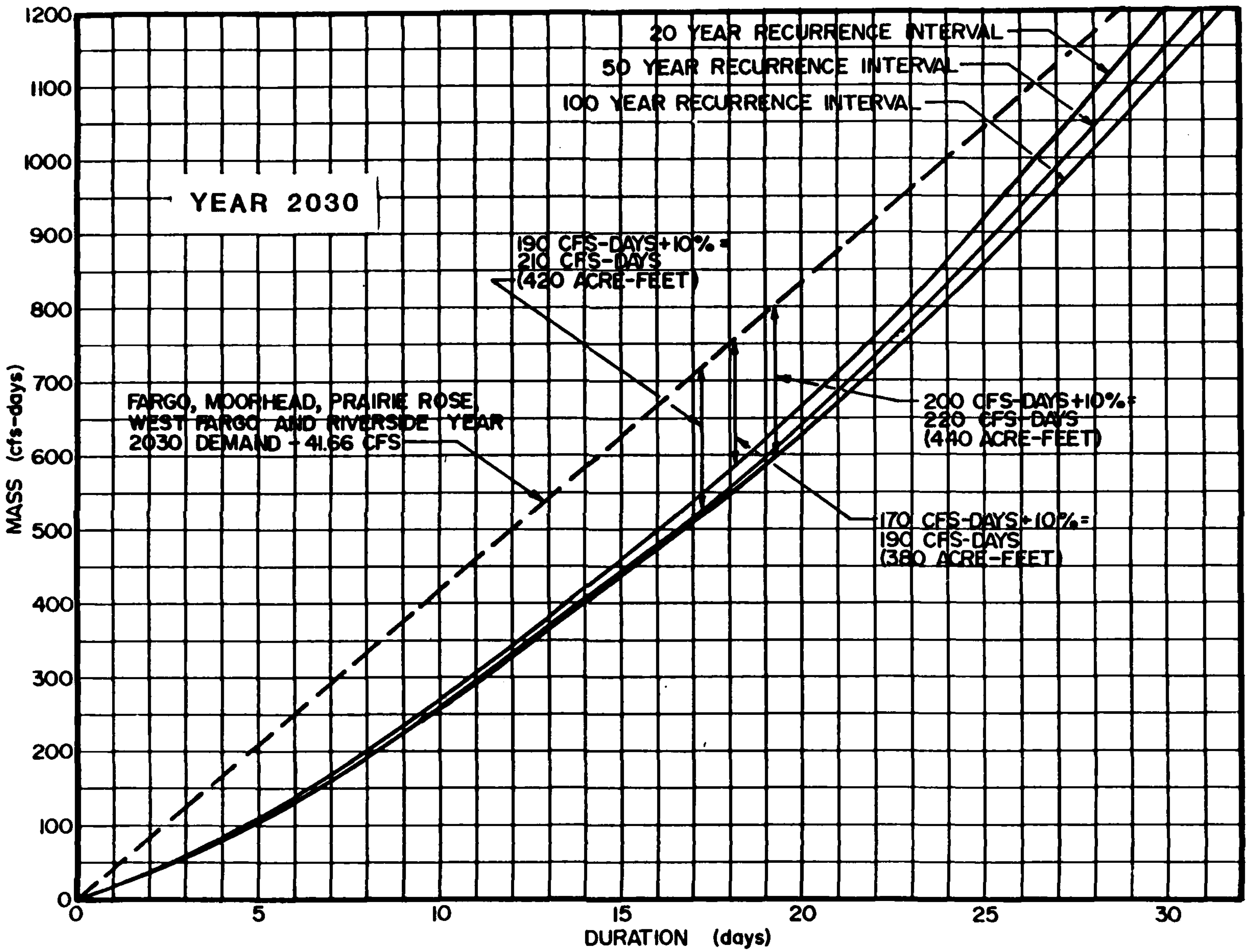


FIGURE 27: Mass Curves for the Sum of the Red River at Fargo and Sheyenne River West Fargo(Alternative 4)

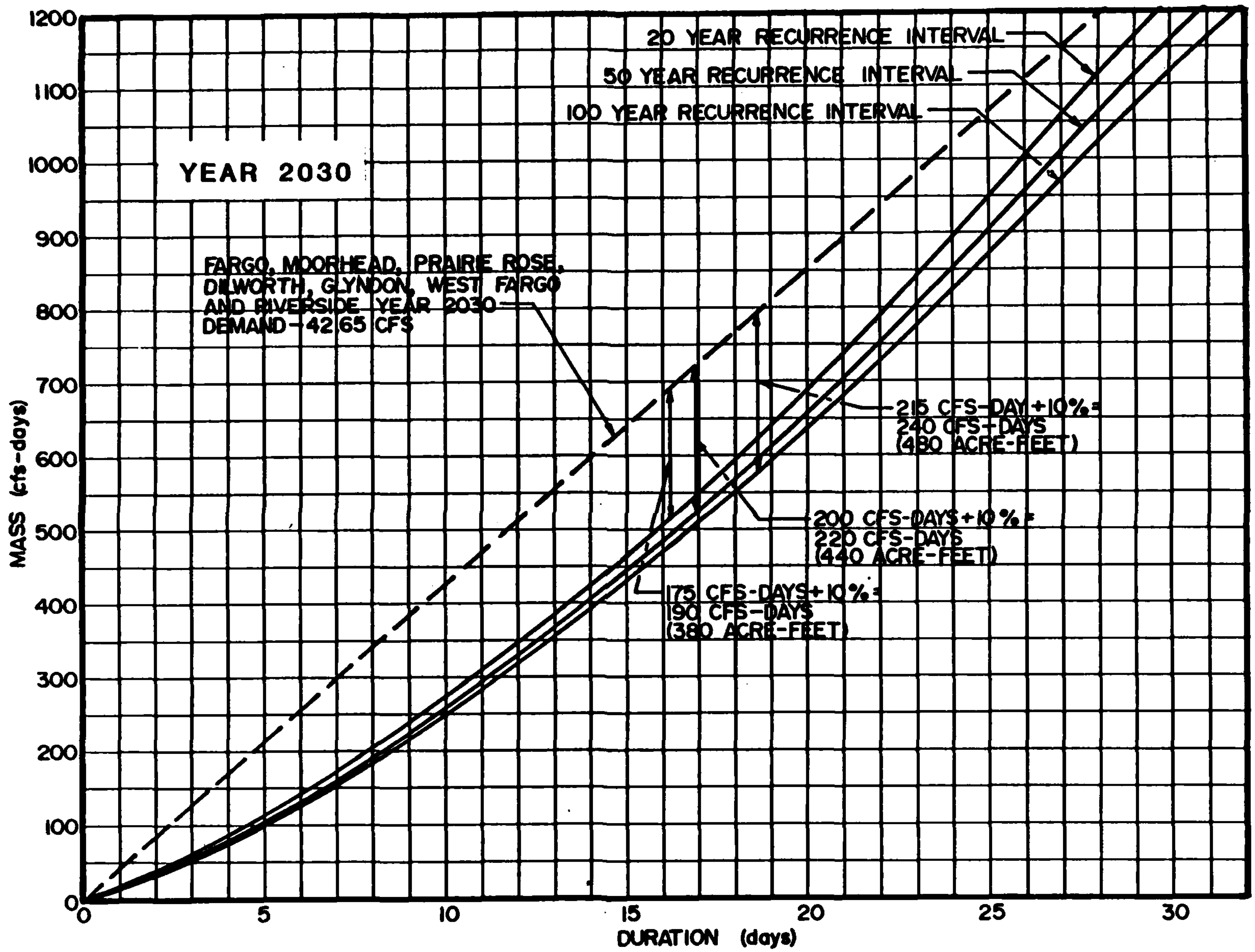


FIGURE 28: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Buffalo River (Alternative 5)

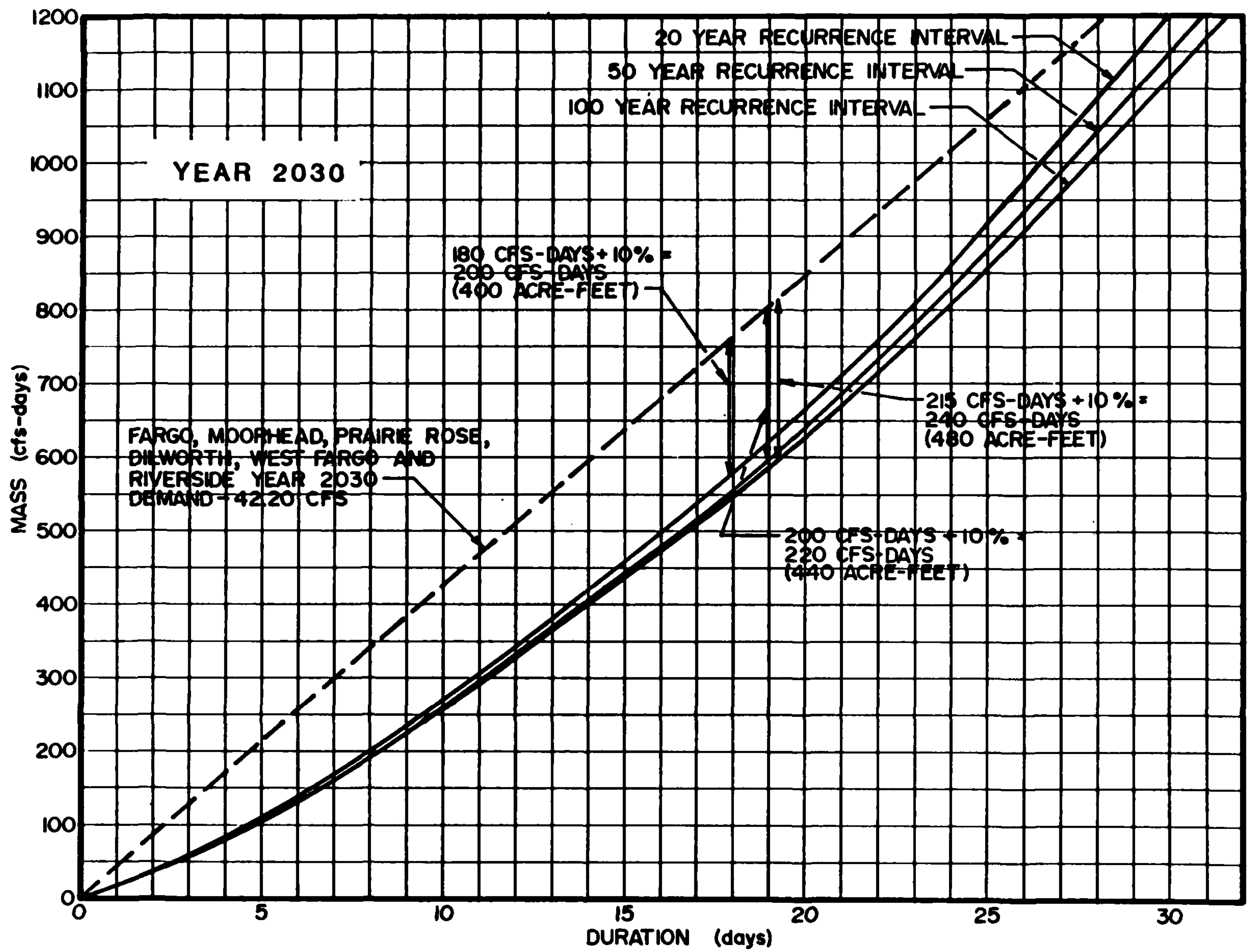


FIGURE 29: Mass Curves for the Sum of the Red River at Fargo and Sheyenne River at West Fargo (Alternative 6)

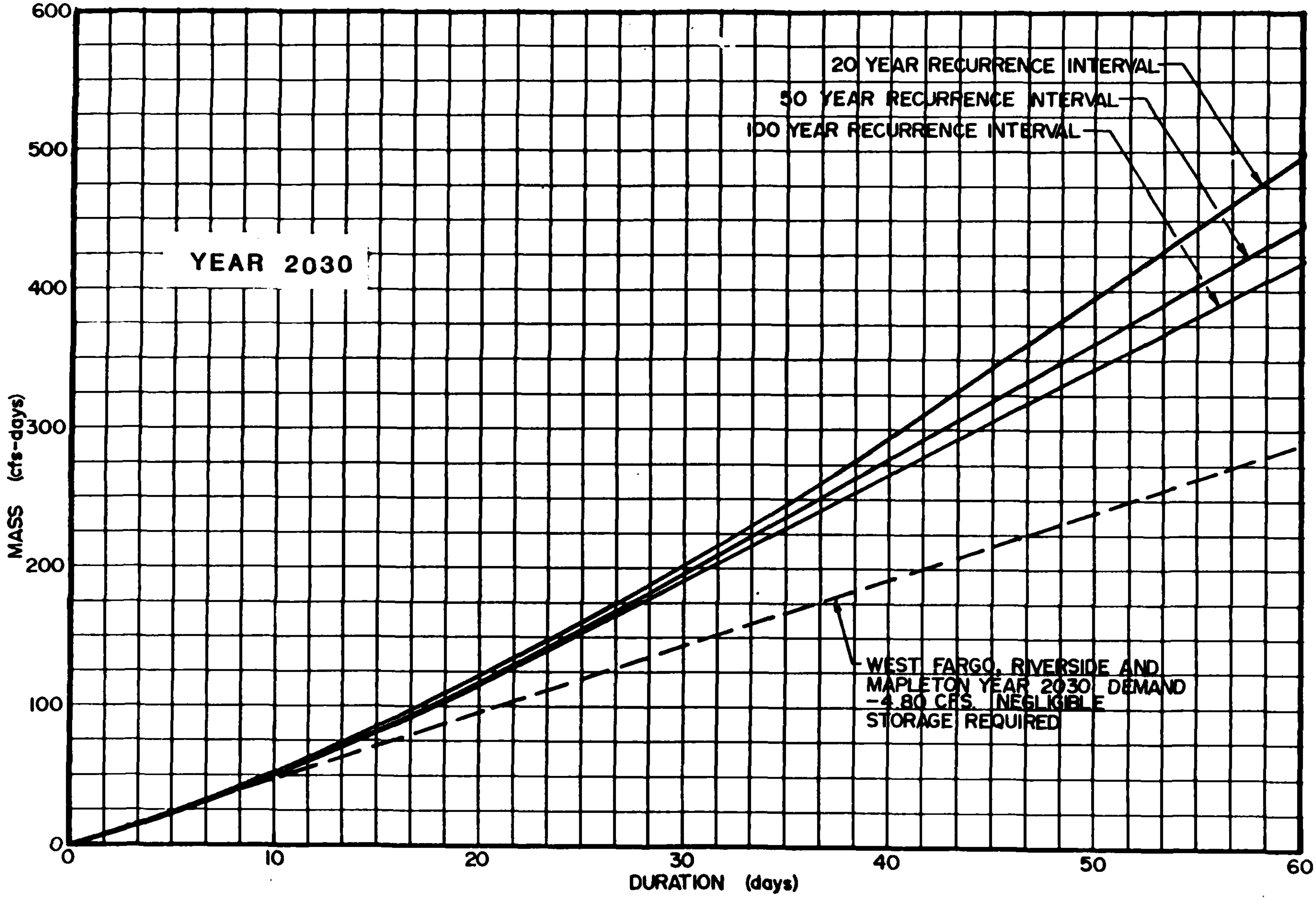


FIGURE 30: Mass Curves for the Sum of the Sheyenne River at West Fargo and Maple River (Alternative 7)

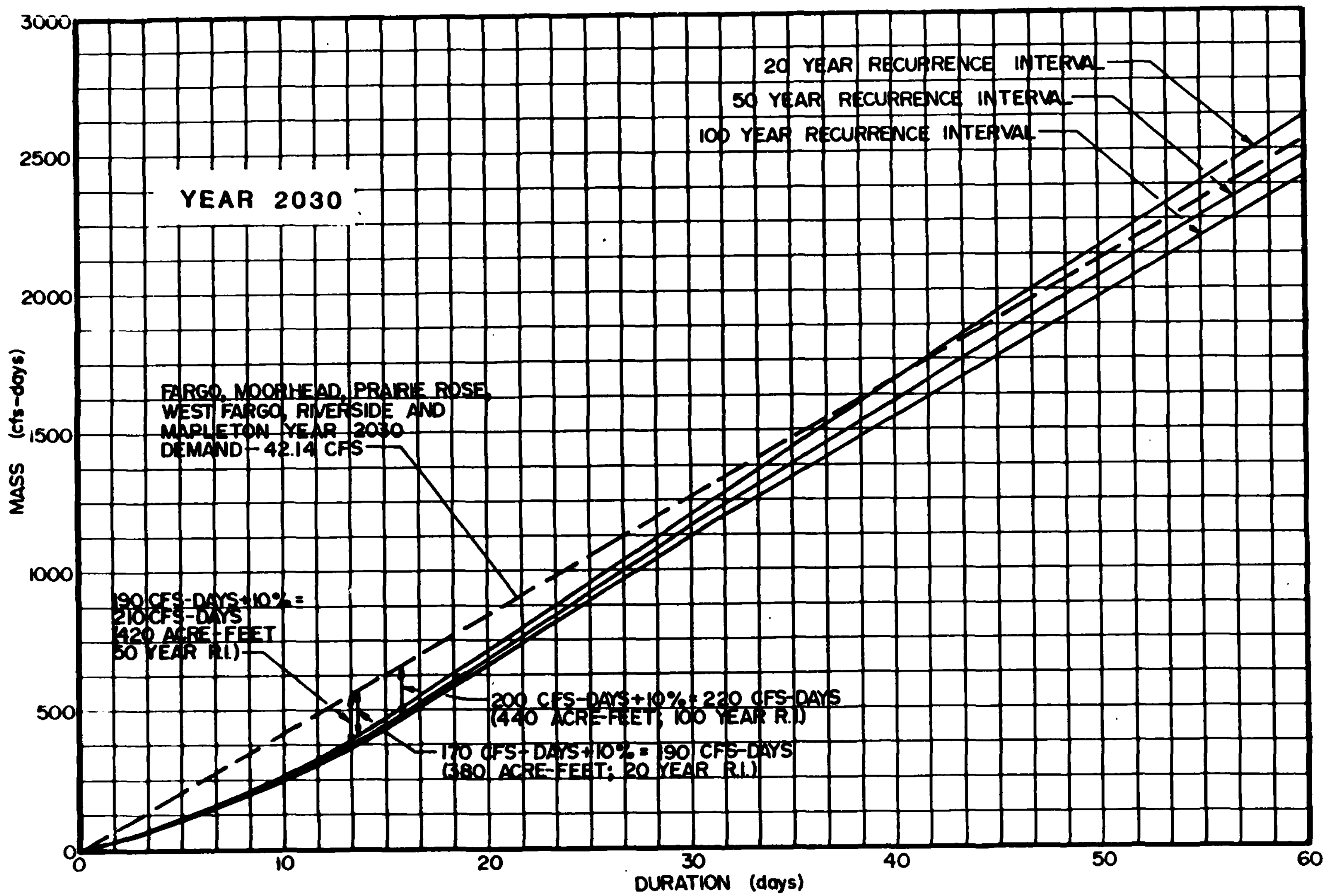


FIGURE 31: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Maple River (Alternative 8)

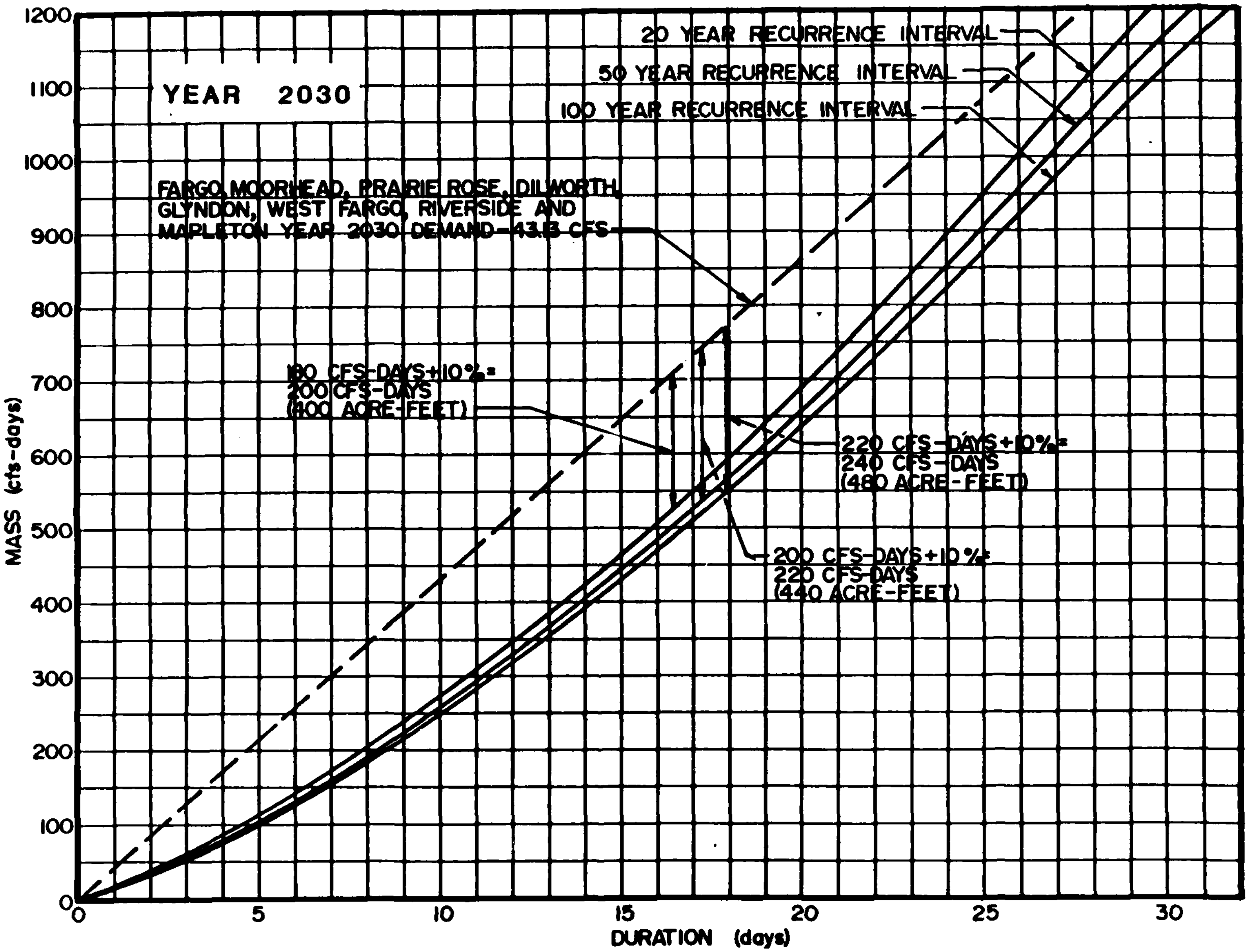


FIGURE 32: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Buffalo and Maple Rivers(Alternative 9)

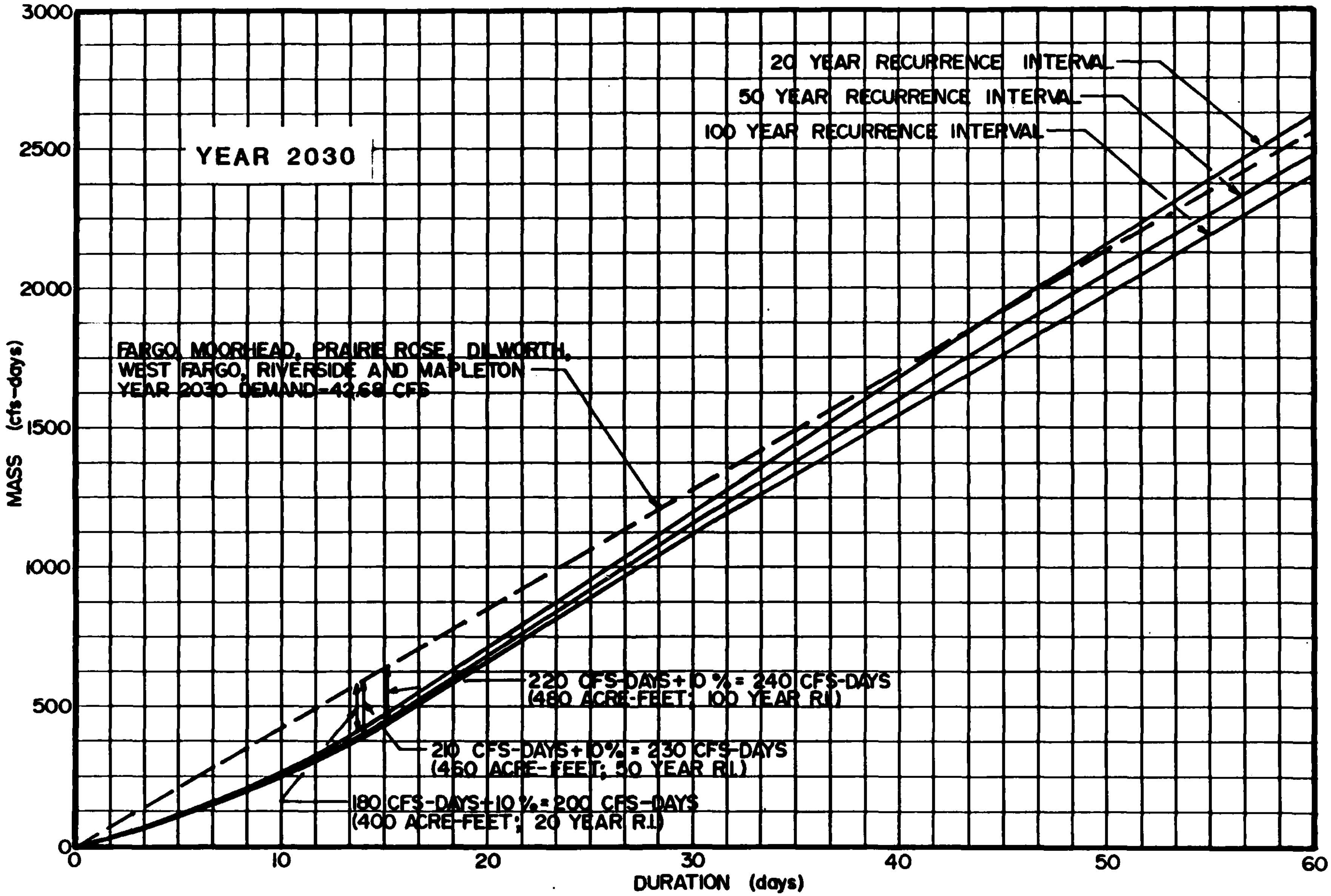


FIGURE 33: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Maple River (Alternative 10)

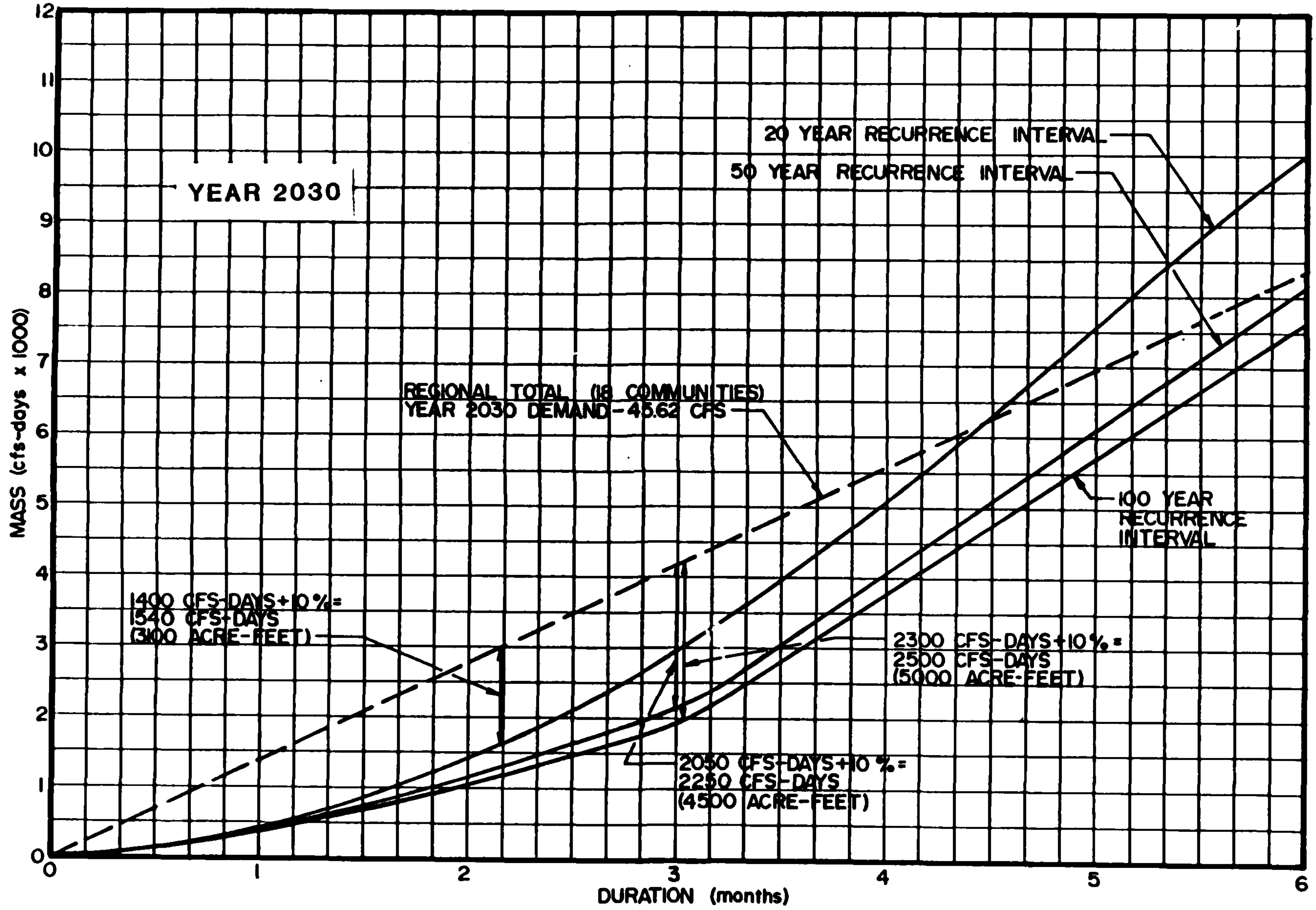


FIGURE 34: Mass Curves for the Sum of the Red River at Rustad, Sheyenne River at Horace, and Buffalo and Maple Rivers (Alternative 11)

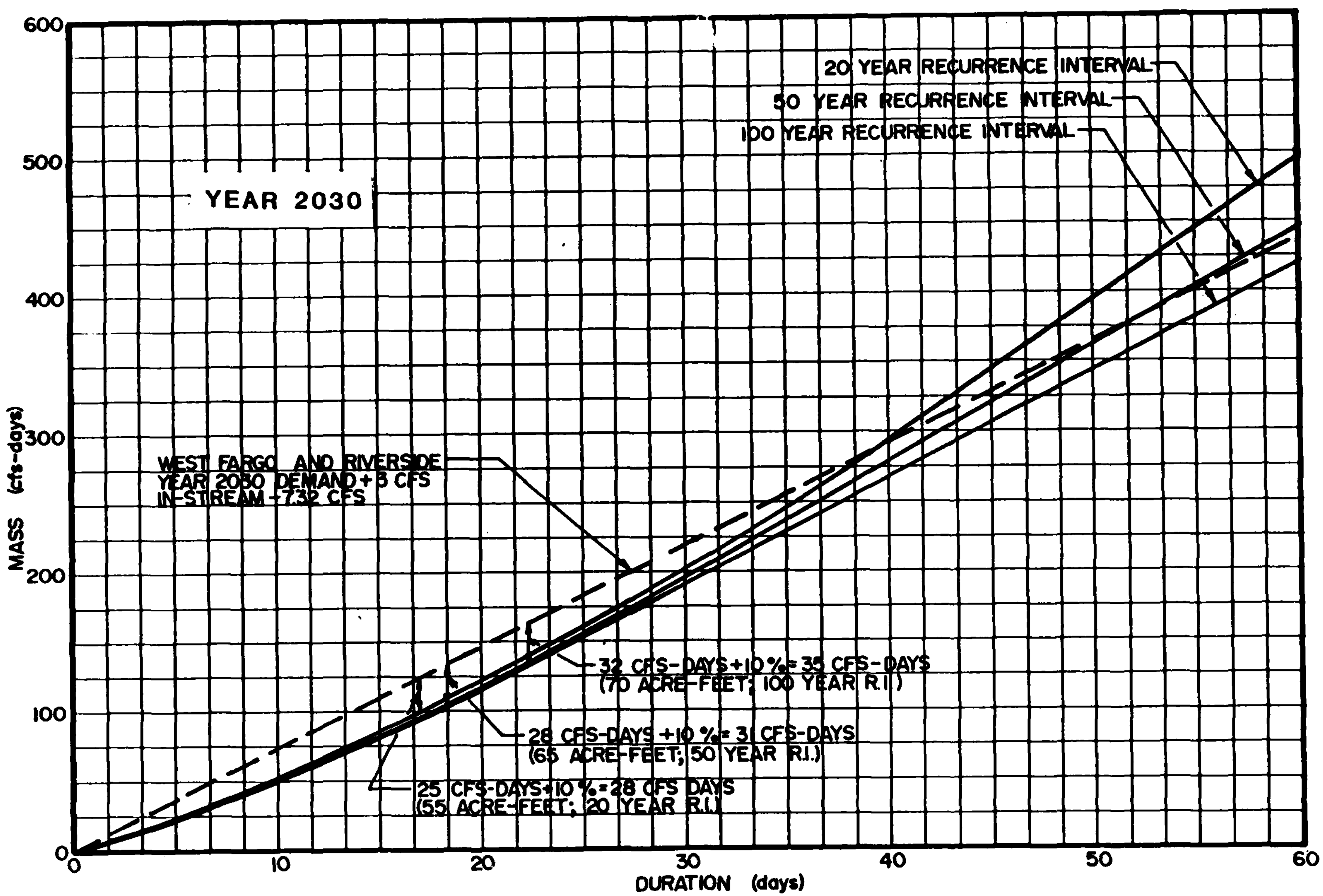


FIGURE 35: Mass Curves for the Sheyenne River at West Fargo (Alternatives 1-3; Minimum In-Stream Flow Considered)

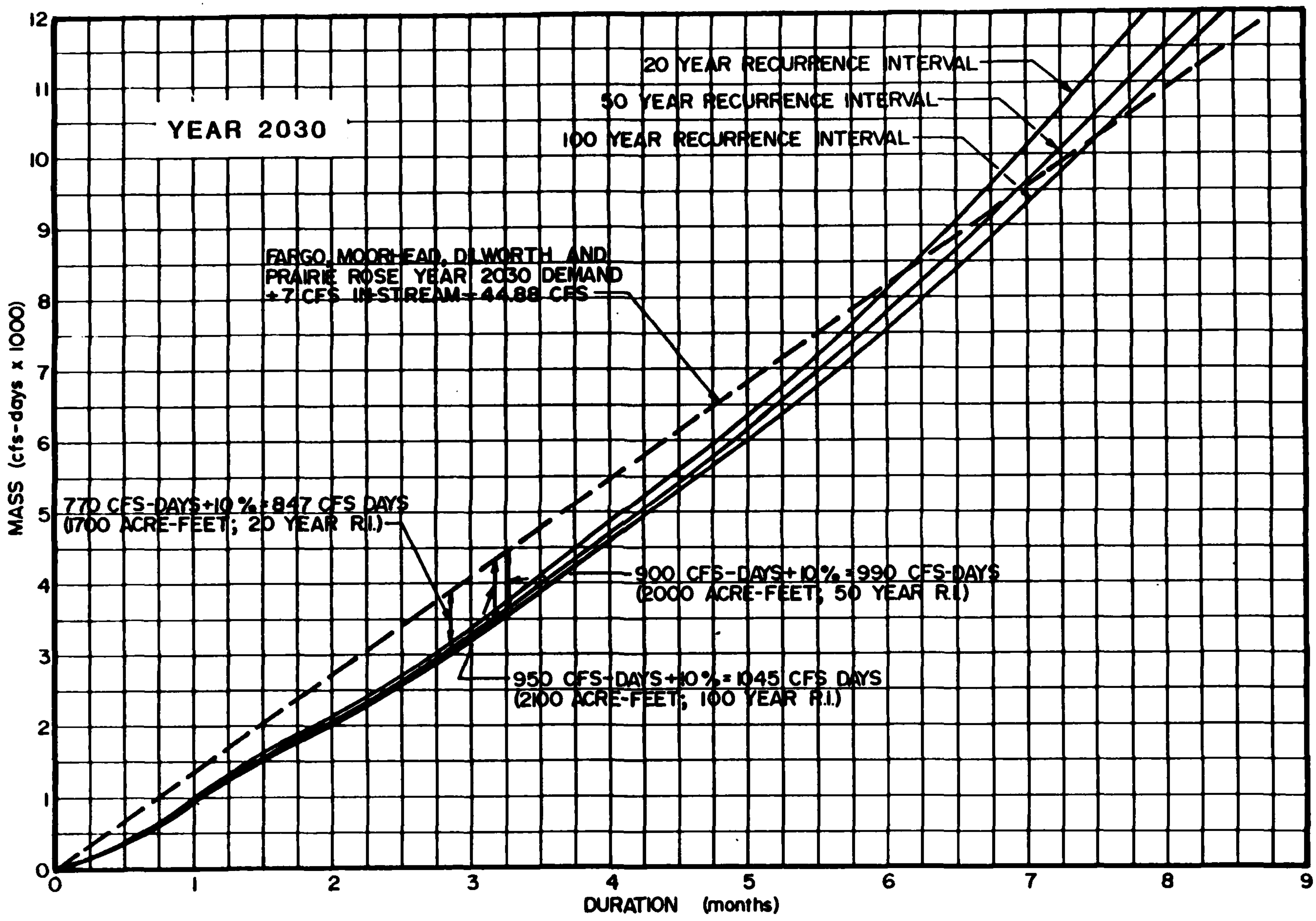


FIGURE 36: Mass Curves for the Red River at Fargo (Alternative 1; Minimum In-Stream Flow Considered)

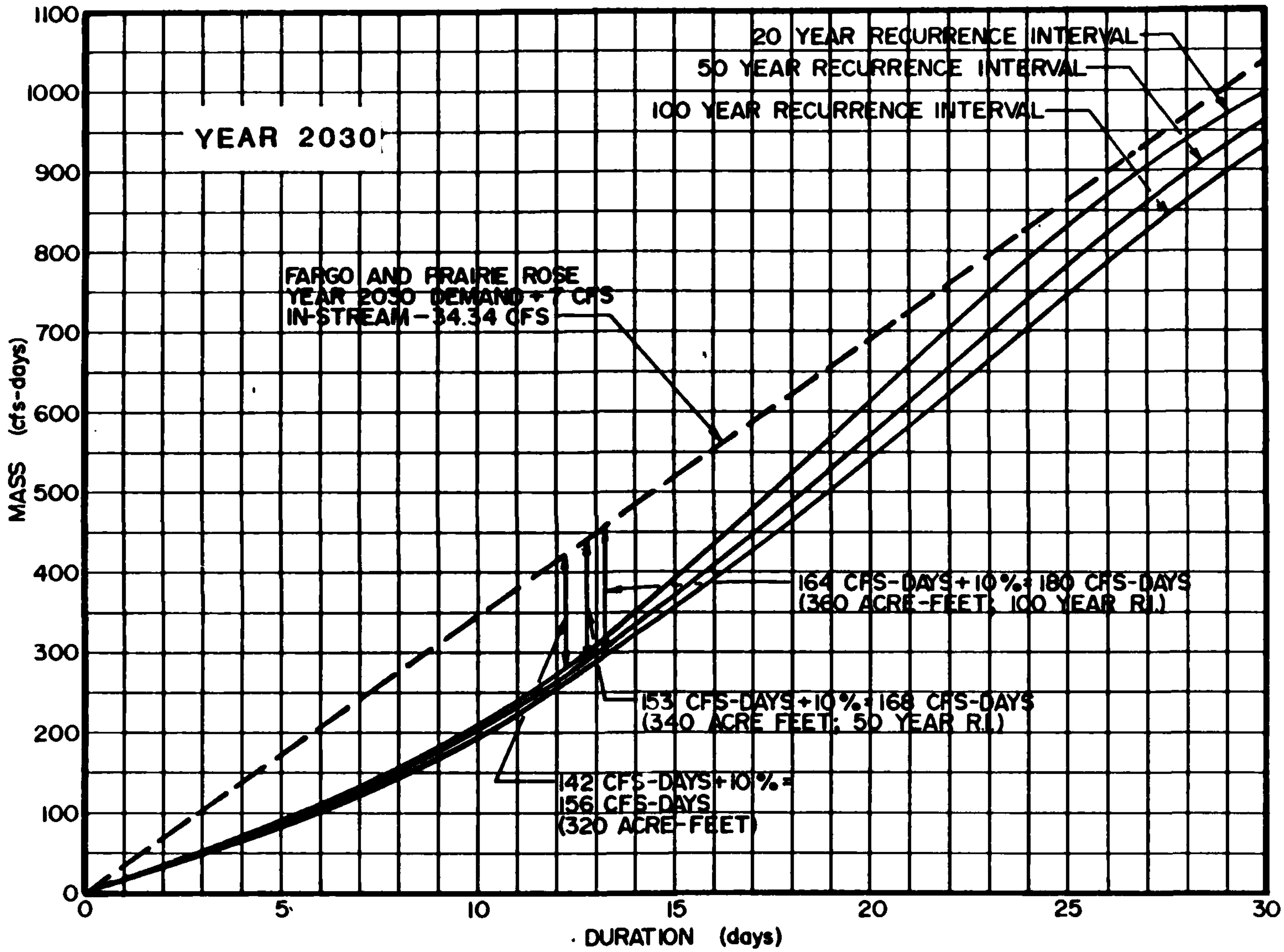


FIGURE 37: Mass Curves for the Red River at Fargo (Alternative 2; Minimum In-Stream Flow Considered)

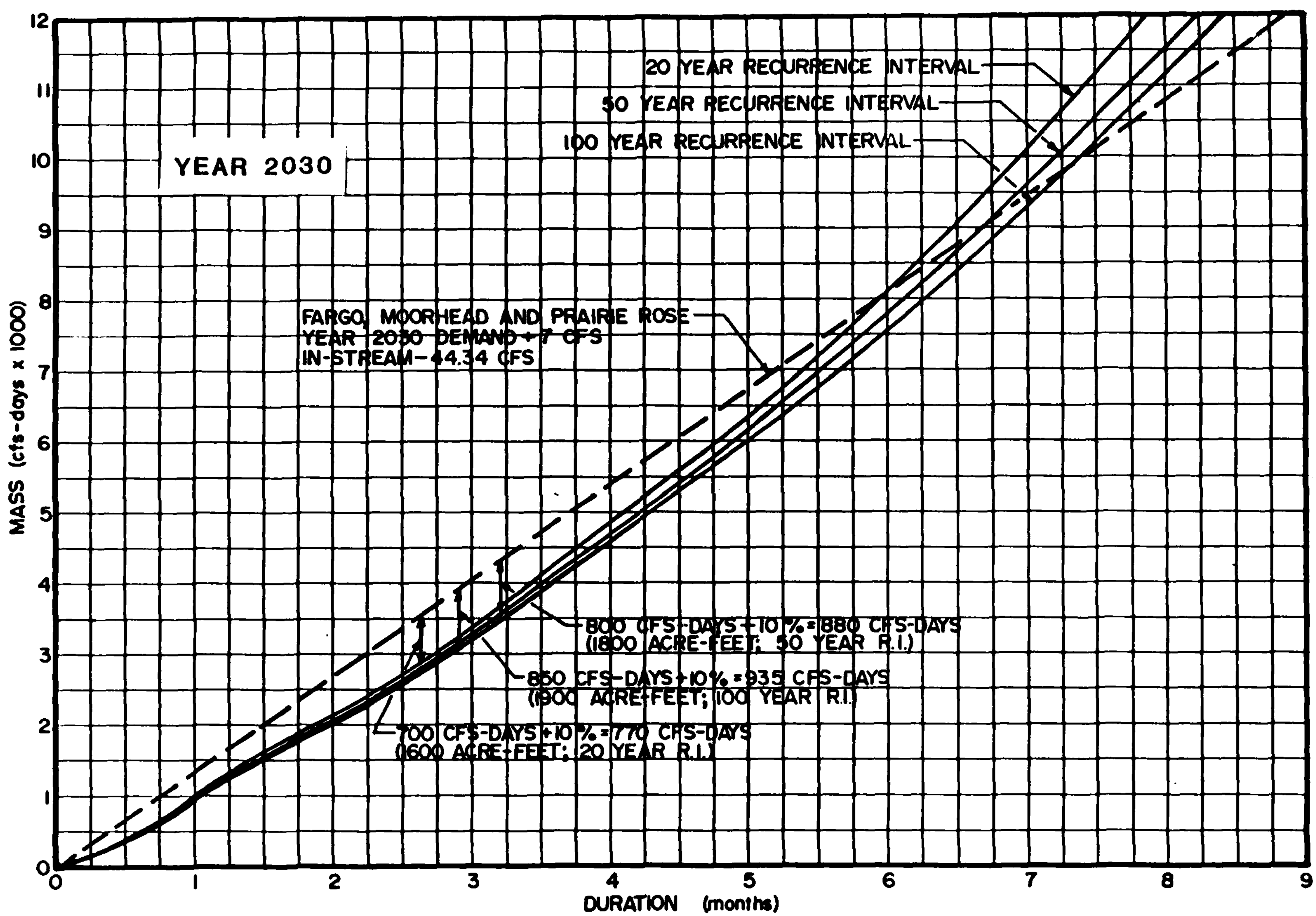


FIGURE 38: Mass Curves for the Red River at Fargo (Alternatives 3 and 7; Minimum In-Stream Flow Considered)

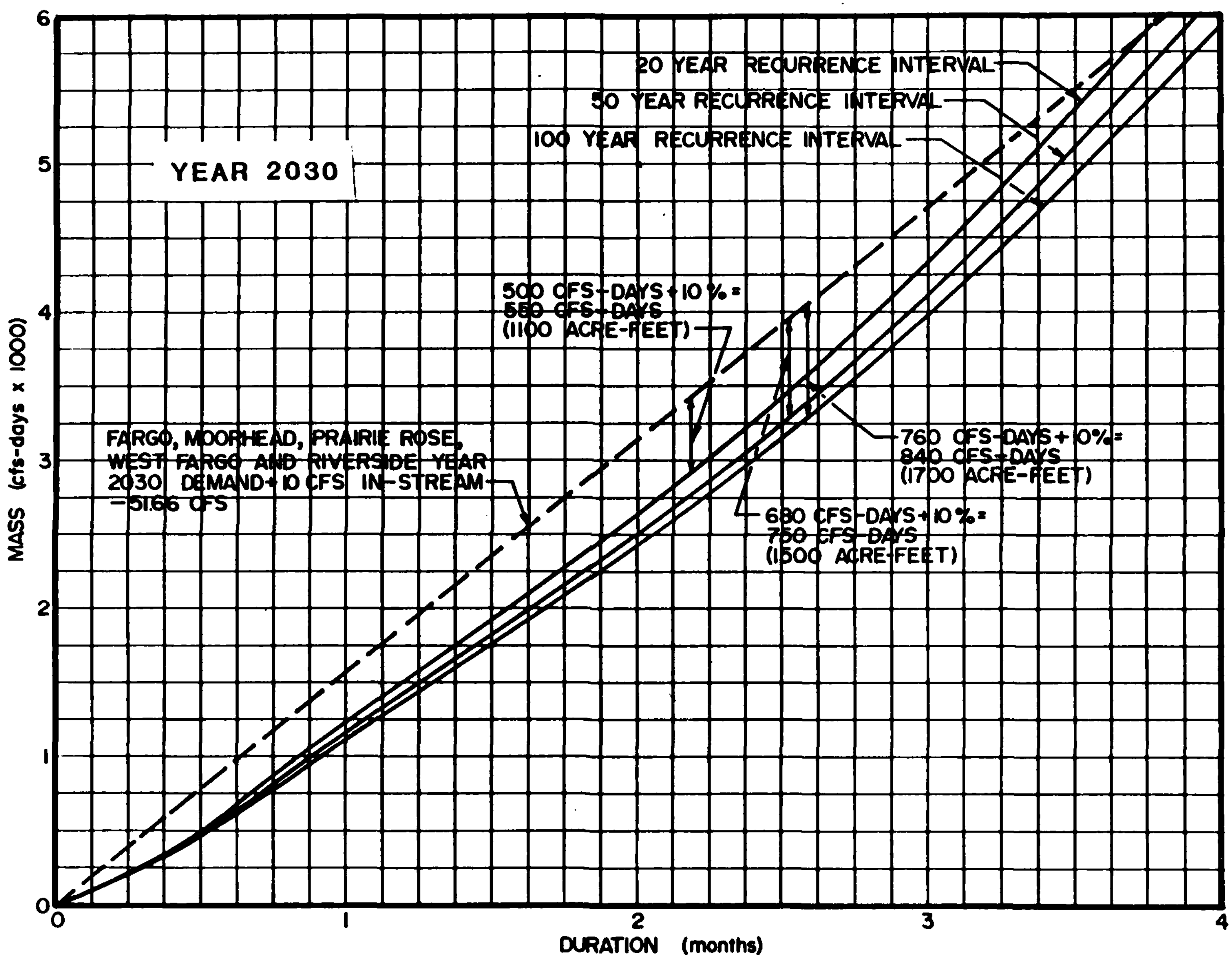


FIGURE 39: Mass Curves for the Sum of the Red River at Fargo and Sheyenne River at West Fargo (Alternative 4; Minimum In-Stream Flows Considered)

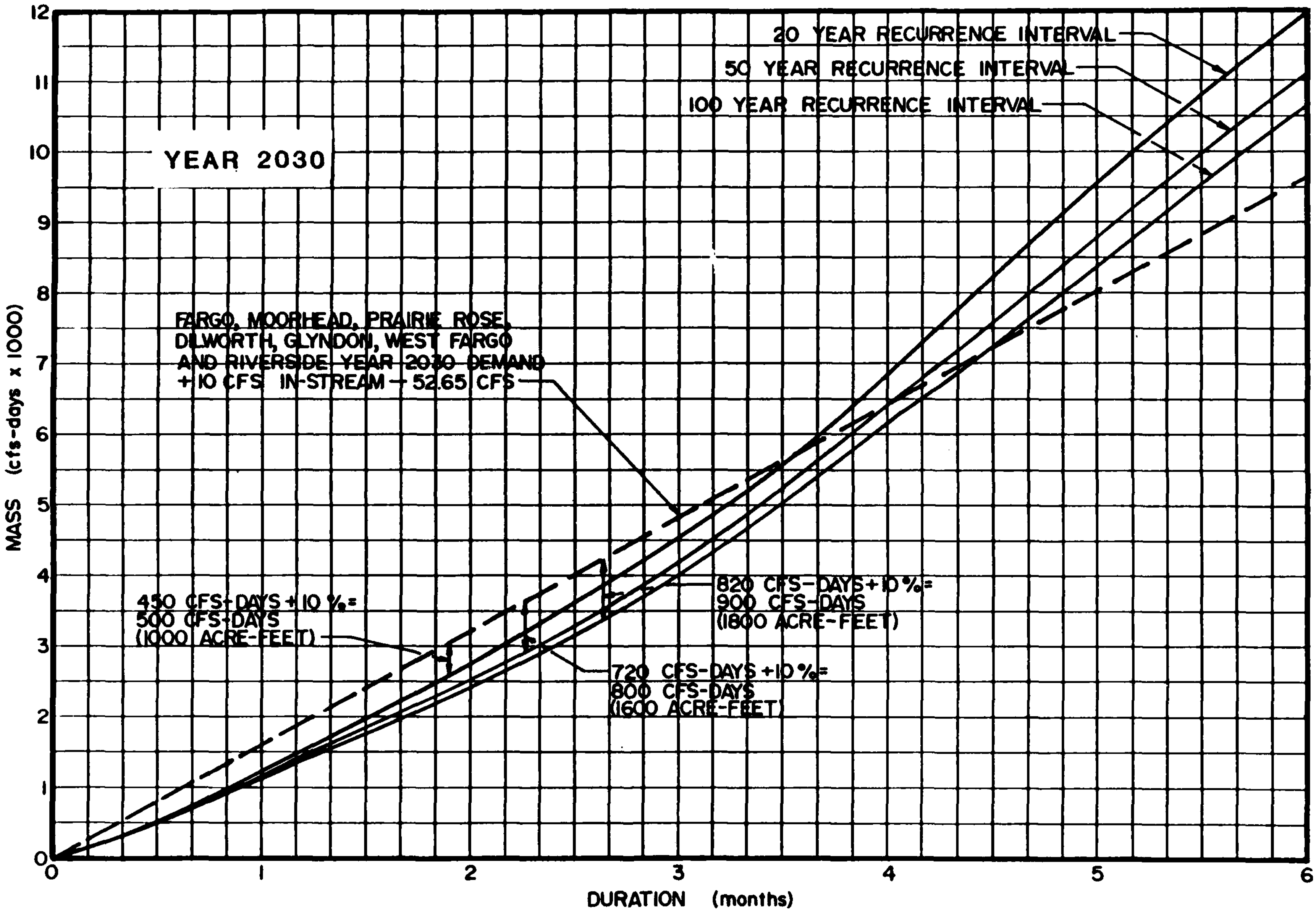


FIGURE 40: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Buffalo River (Alternative 5; Minimum In-Stream Flows Considered)

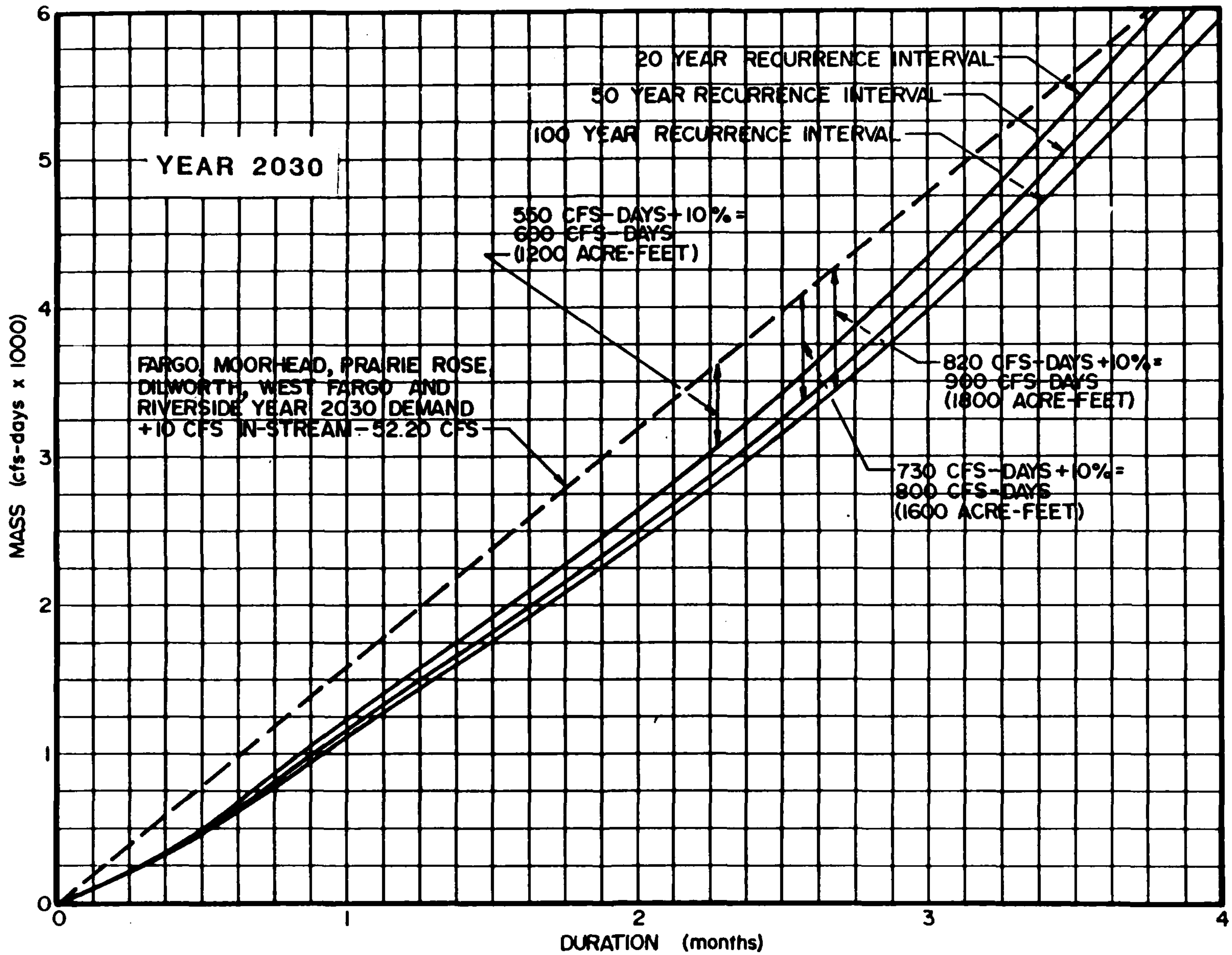


FIGURE 41: Mass Curves for the Sum of the Red River at Fargo and Sheyenne River at West Fargo (Alternative 6; Minimum In-Stream Flows Considered)

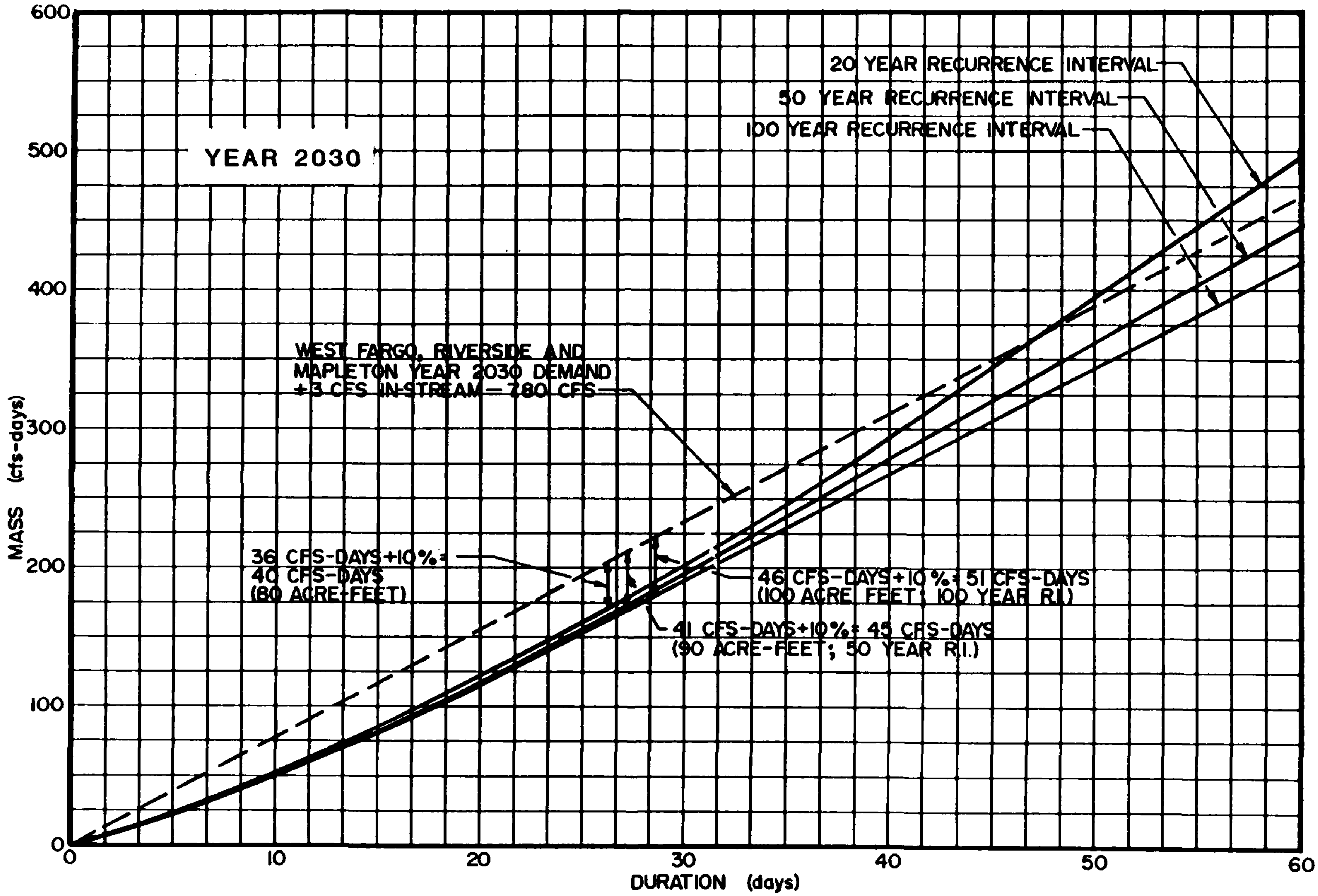


FIGURE 42: Mass Curves for the Sum of the Sheyenne River at West Fargo and Maple River (Alternative 7; Minimum In-Stream Flow Considered)

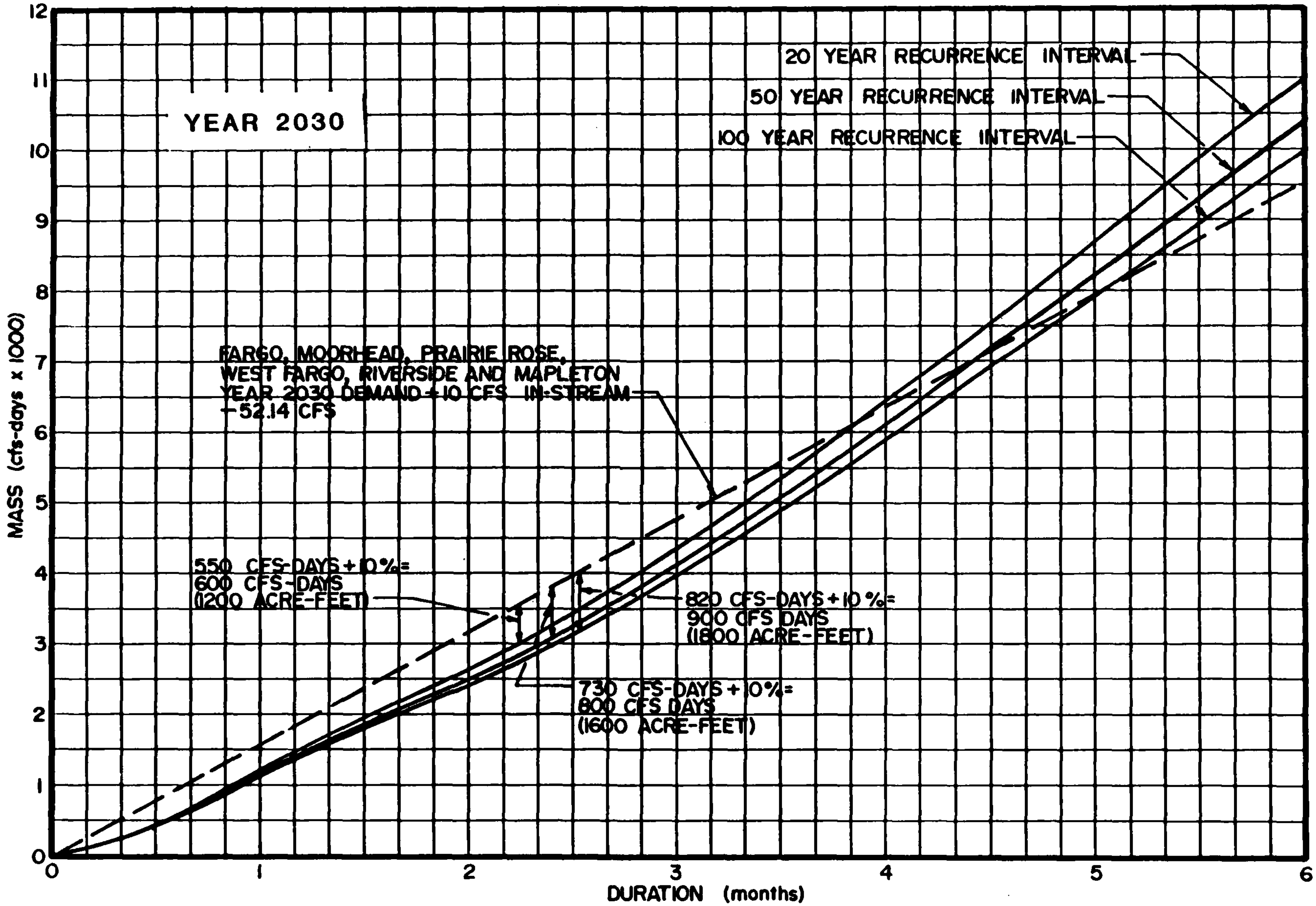


FIGURE 43: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Maple River (Alternative 8; Minimum In-Stream Flows Considered)

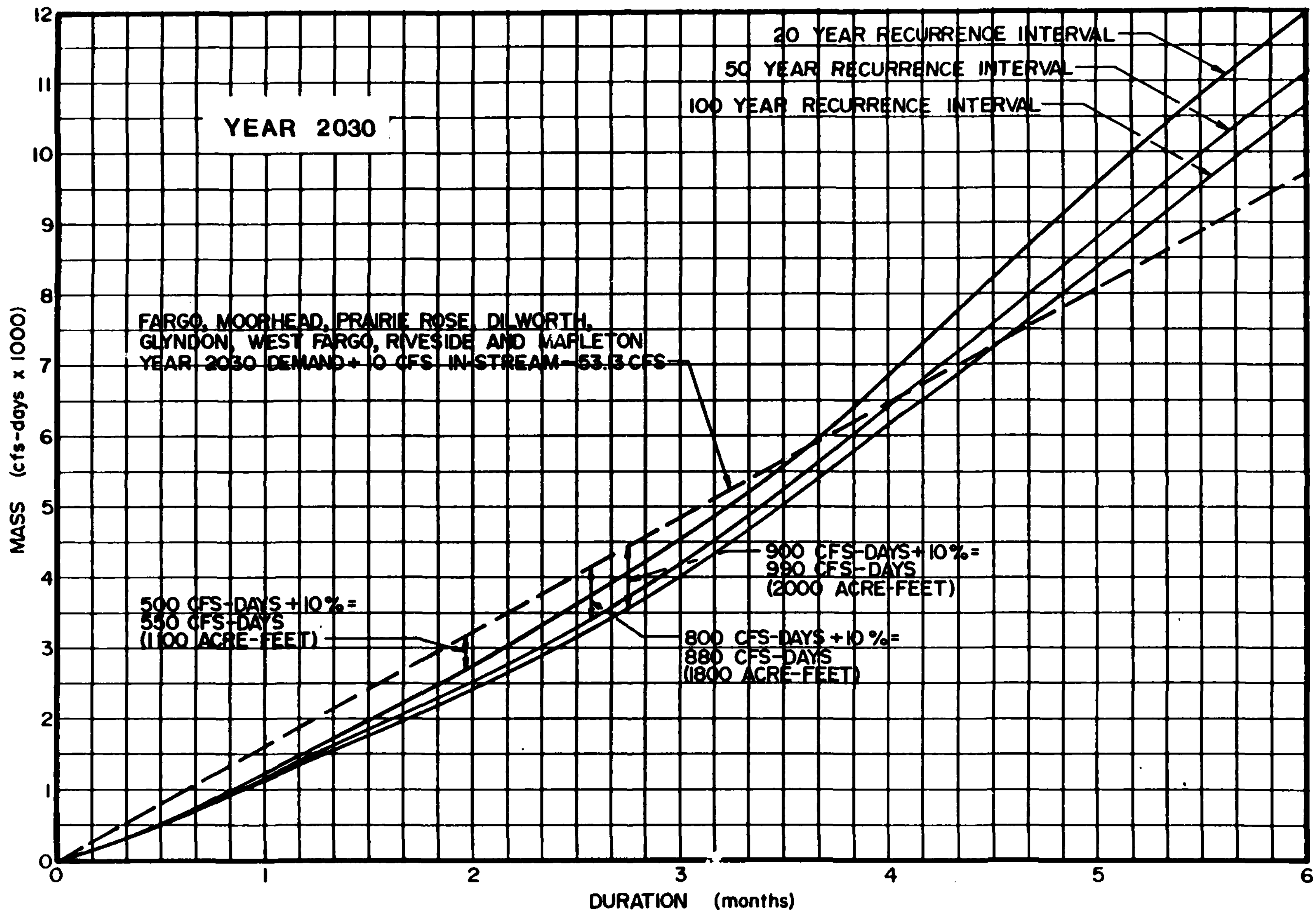


FIGURE 44: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Buffalo and Maple Rivers (Alternative 9; Minimum In-Stream Flows Considered)

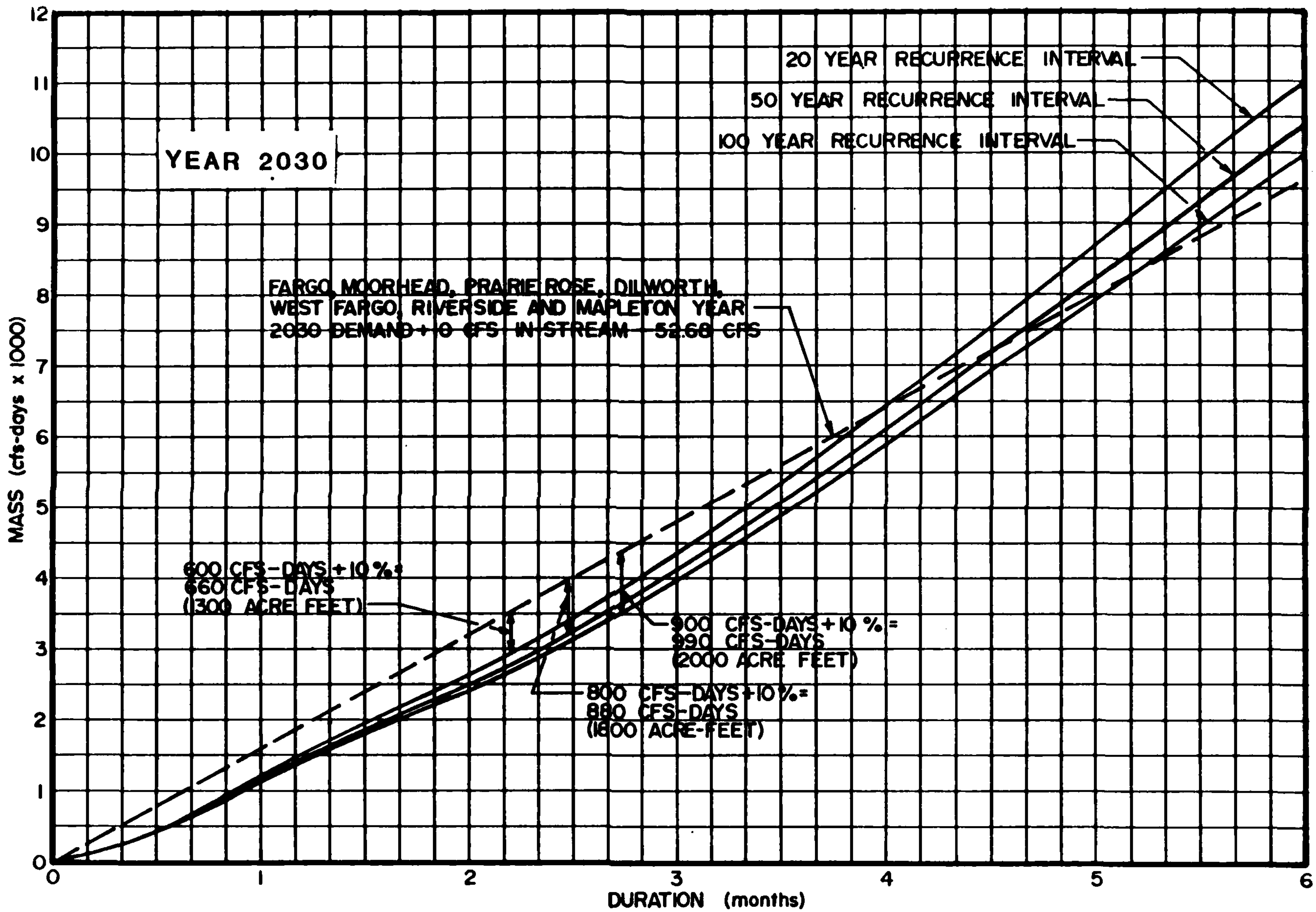


FIGURE 45: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Maple River (Alternative 10; Minimum In-Stream Flows Considered)

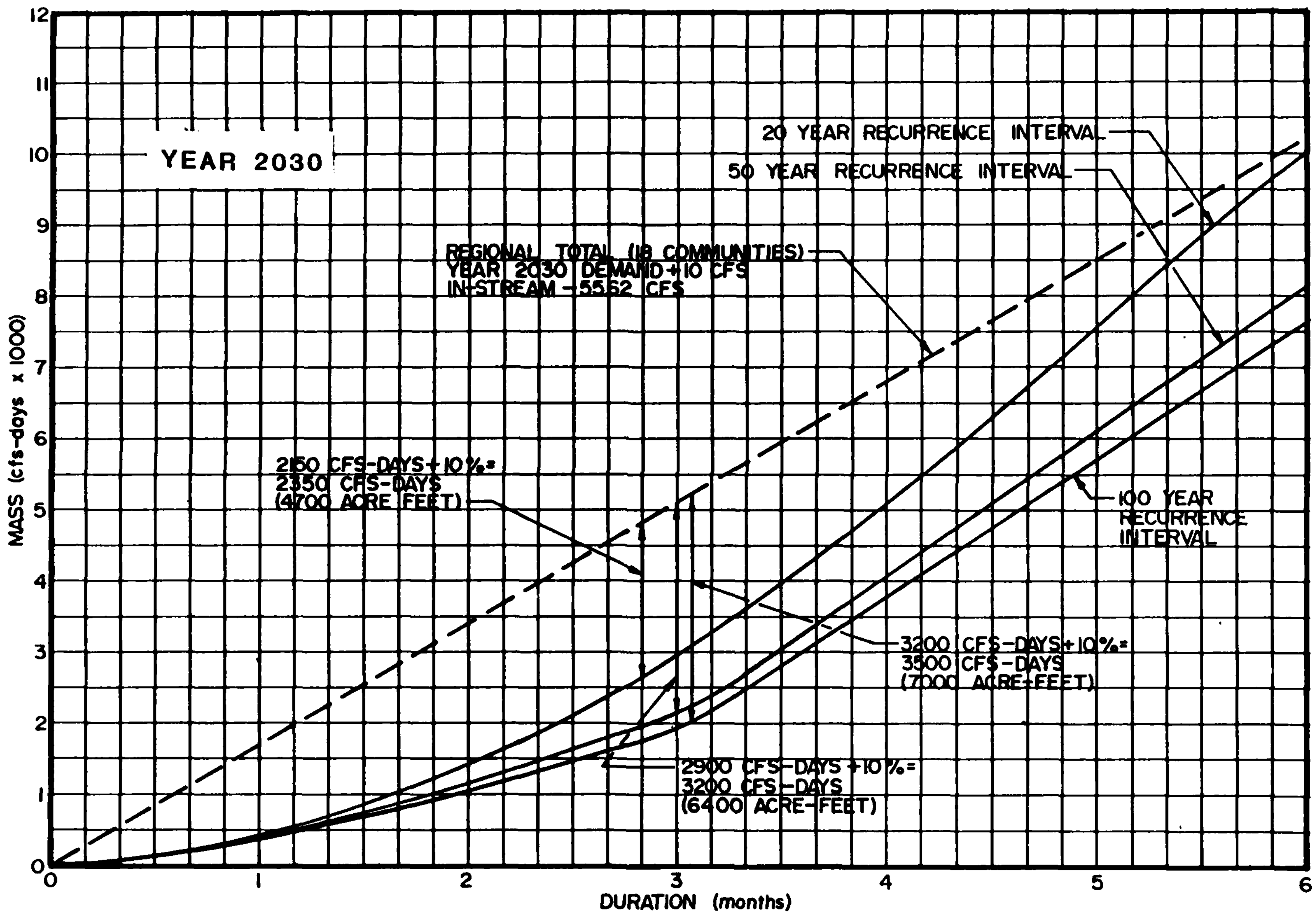


FIGURE 46: Mass Curves for the Sum of the Red River at Rustad, Sheyenne River at Horace, and Buffalo and Maple Rivers (Alternacive 11; Minimum In-Stream Flows Considered)

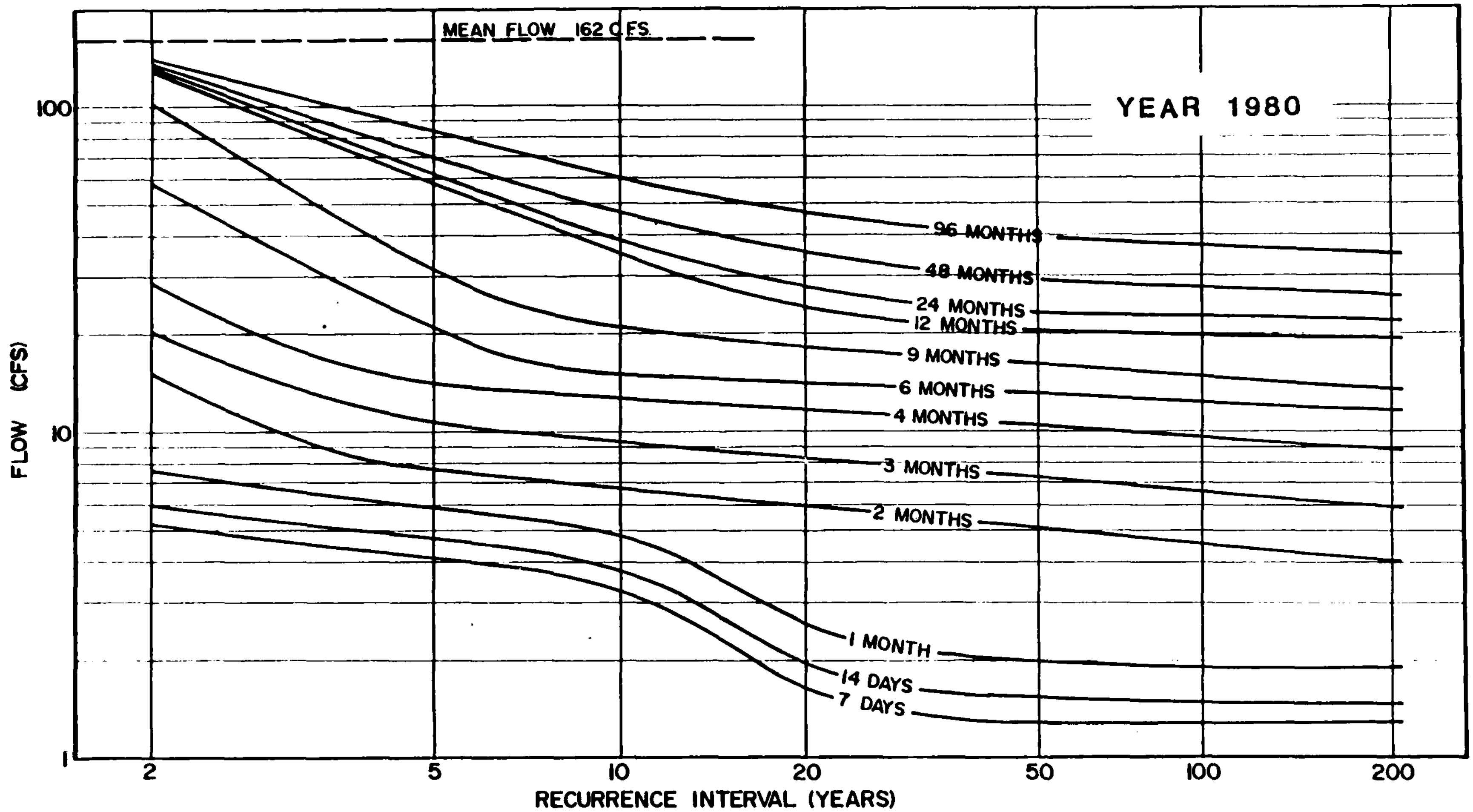


FIGURE 47: Low-Flow Frequency Curves, Sheyenne River at Horace - Year 1980 Case

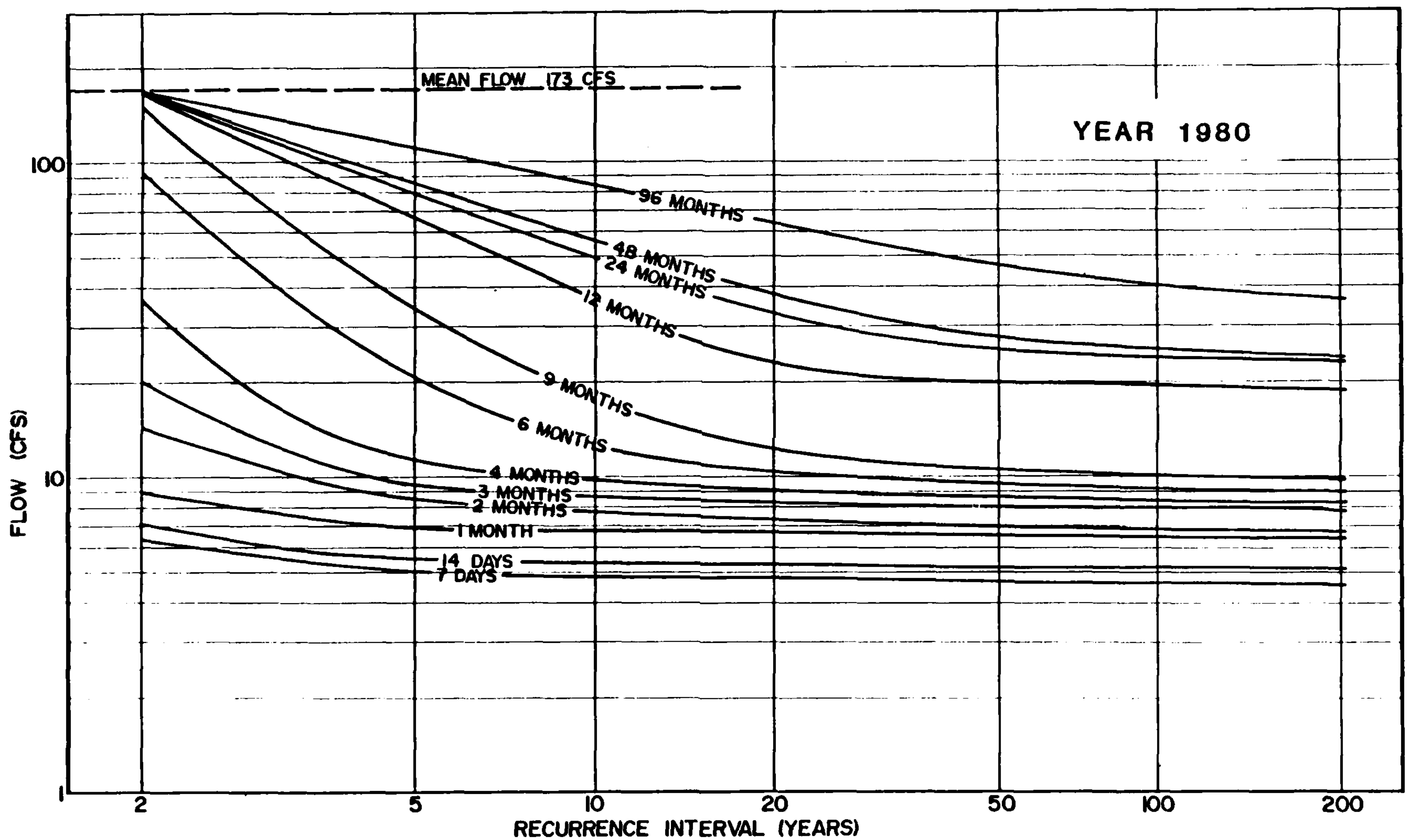


FIGURE 48: Low-Flow Frequency Curves, Sheyenne River at West Fargo - Year 1980 Case

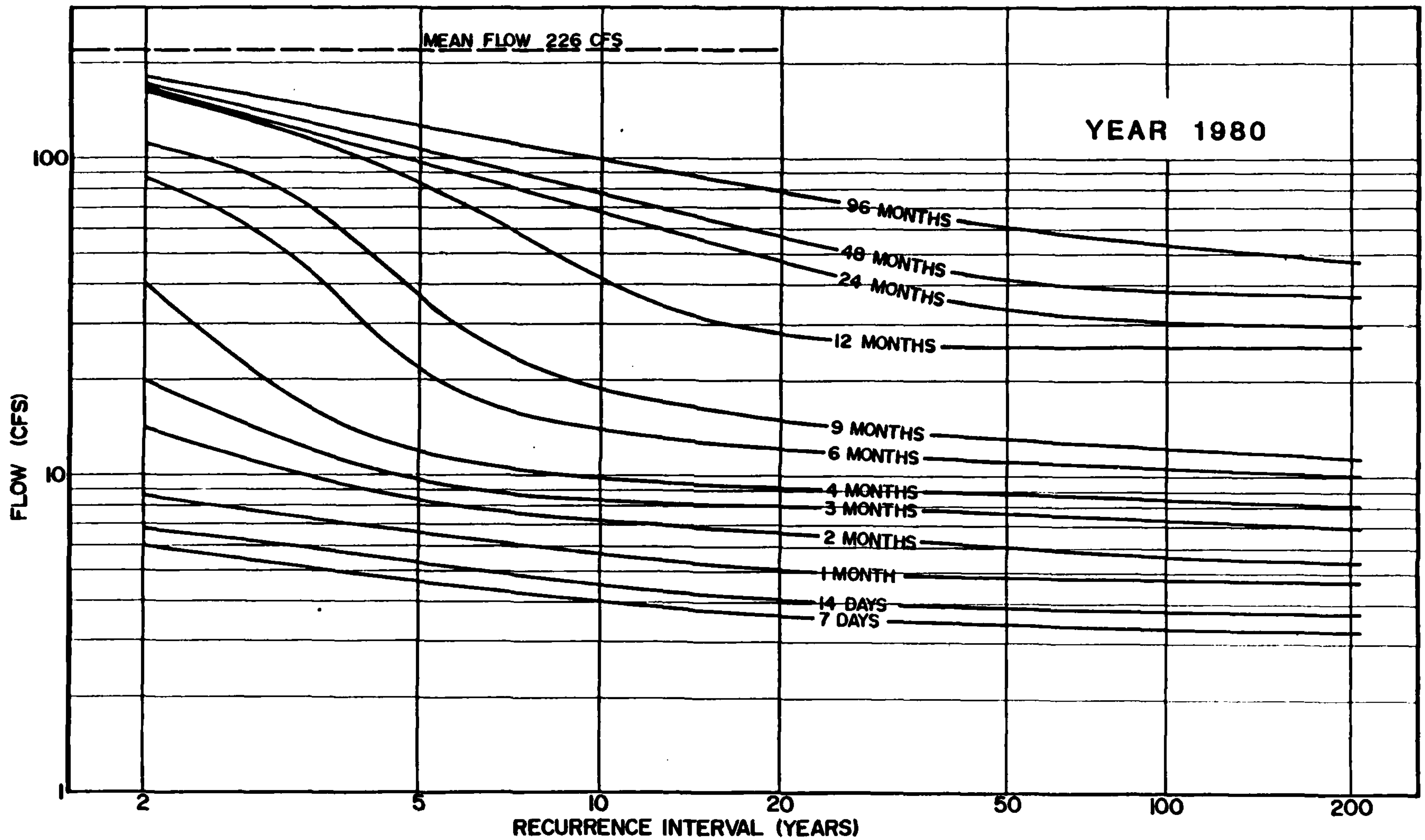


FIGURE 49: Low-Flow Frequency Curves, Sheyenne River at Reile's Acres - Year 1980 Case

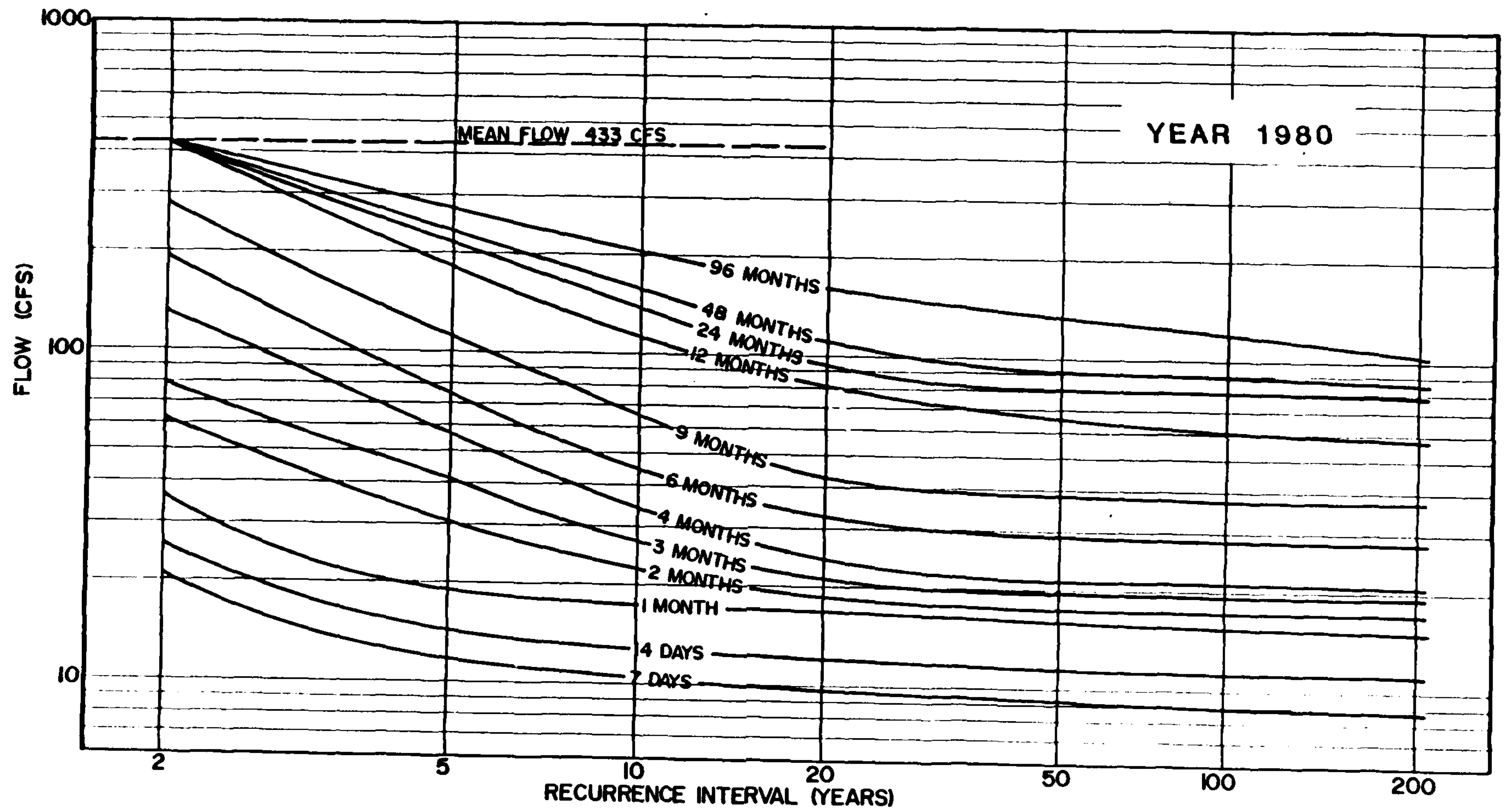


FIGURE 50: Low-Flow Frequency Curves, Red River at Rustad - Year 1980 Case

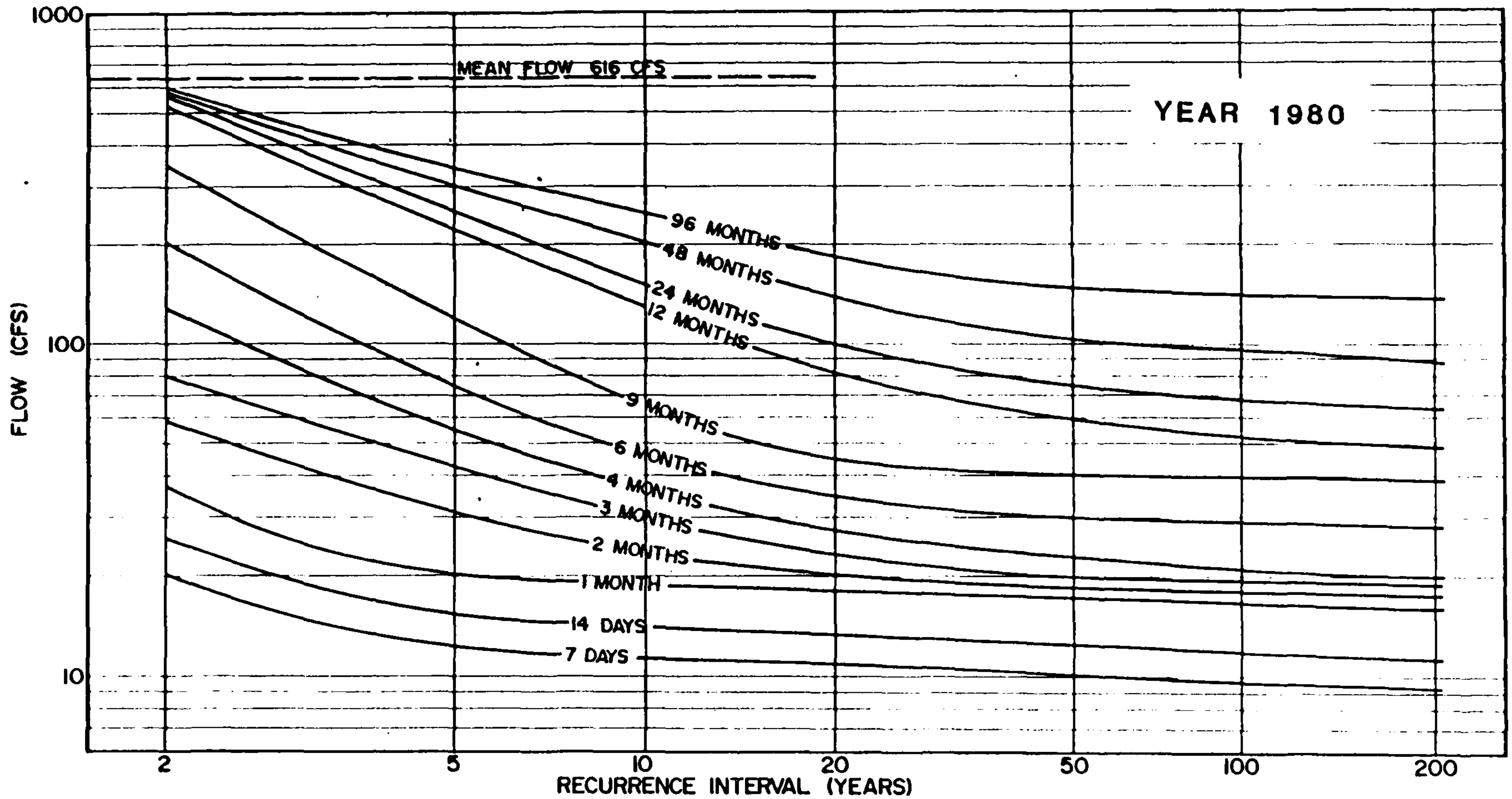


FIGURE 51: Low-Flow Frequency Curves, Red River at Briarwood - Year 1980 Case

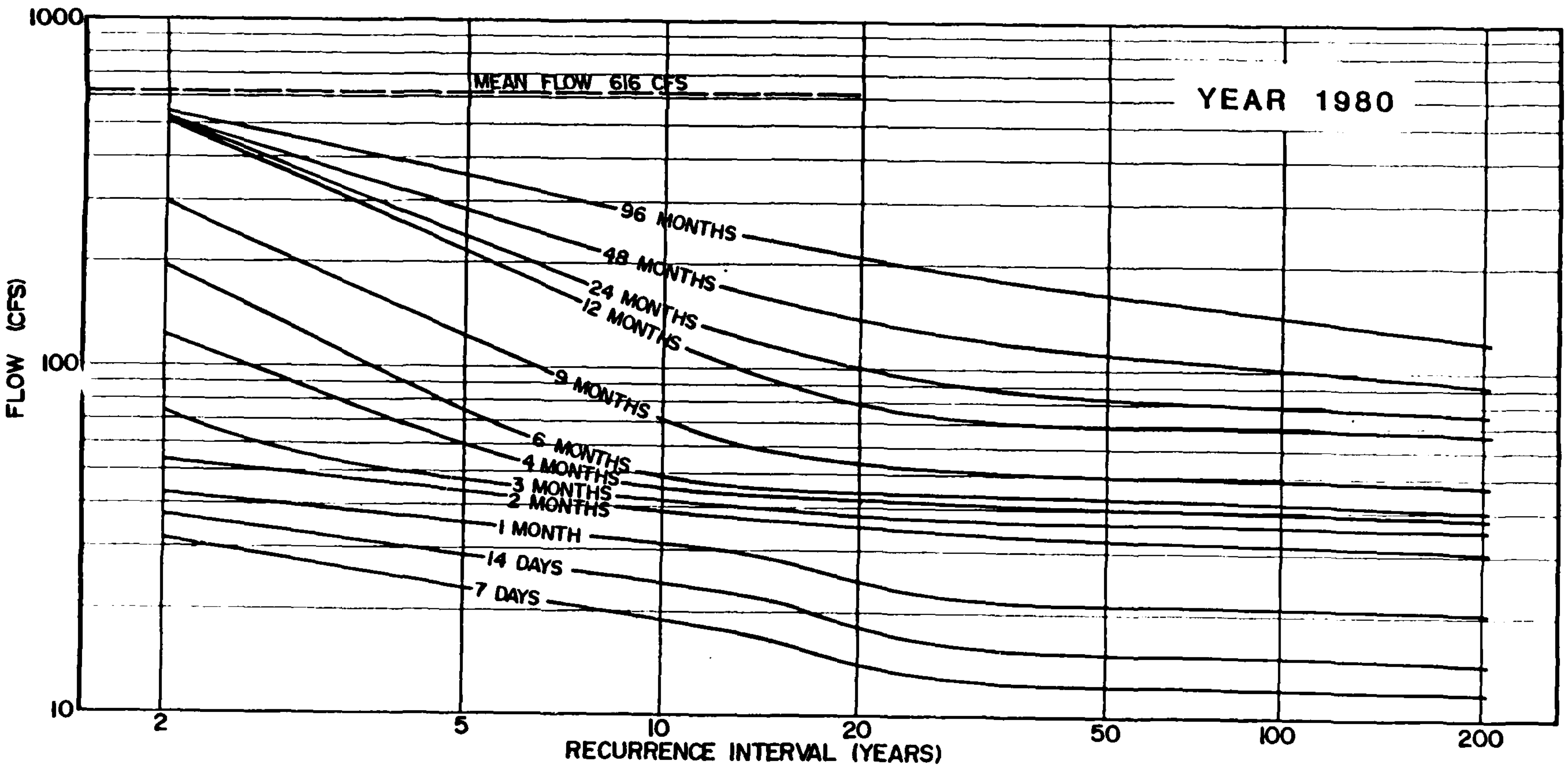


FIGURE 52: Low-Flow Frequency Curves, Red River at Fargo - Year 1980 Case

NOTE: This figure is a graphical presentation of data considering the effect of the Sheyenne diversion. The counterpart to this figure, considering the recently completed Sheyenne pipeline is included in Appendix A.

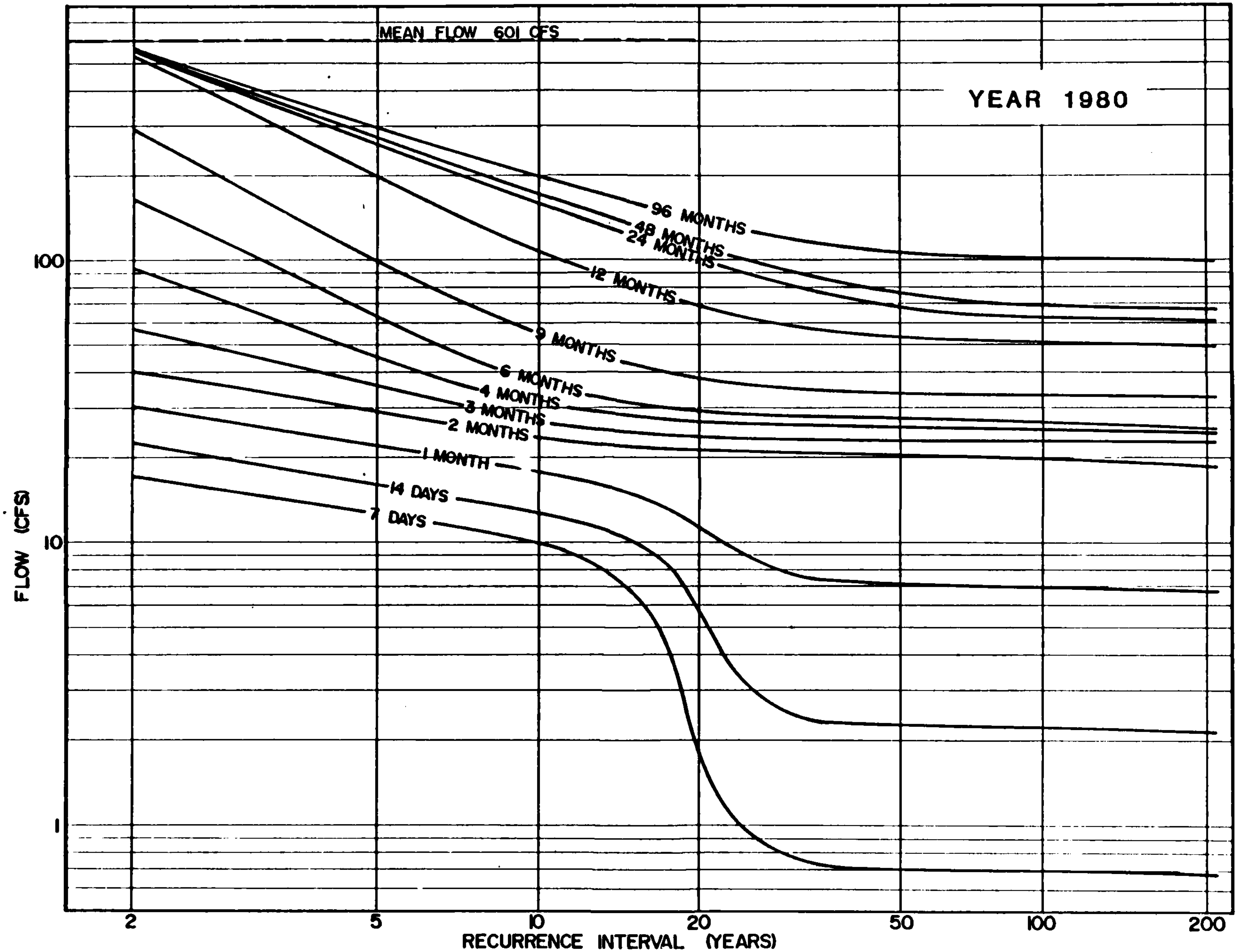


FIGURE 53: Low-Flow Frequency Curves, Red River at North River - Year 1980 Case

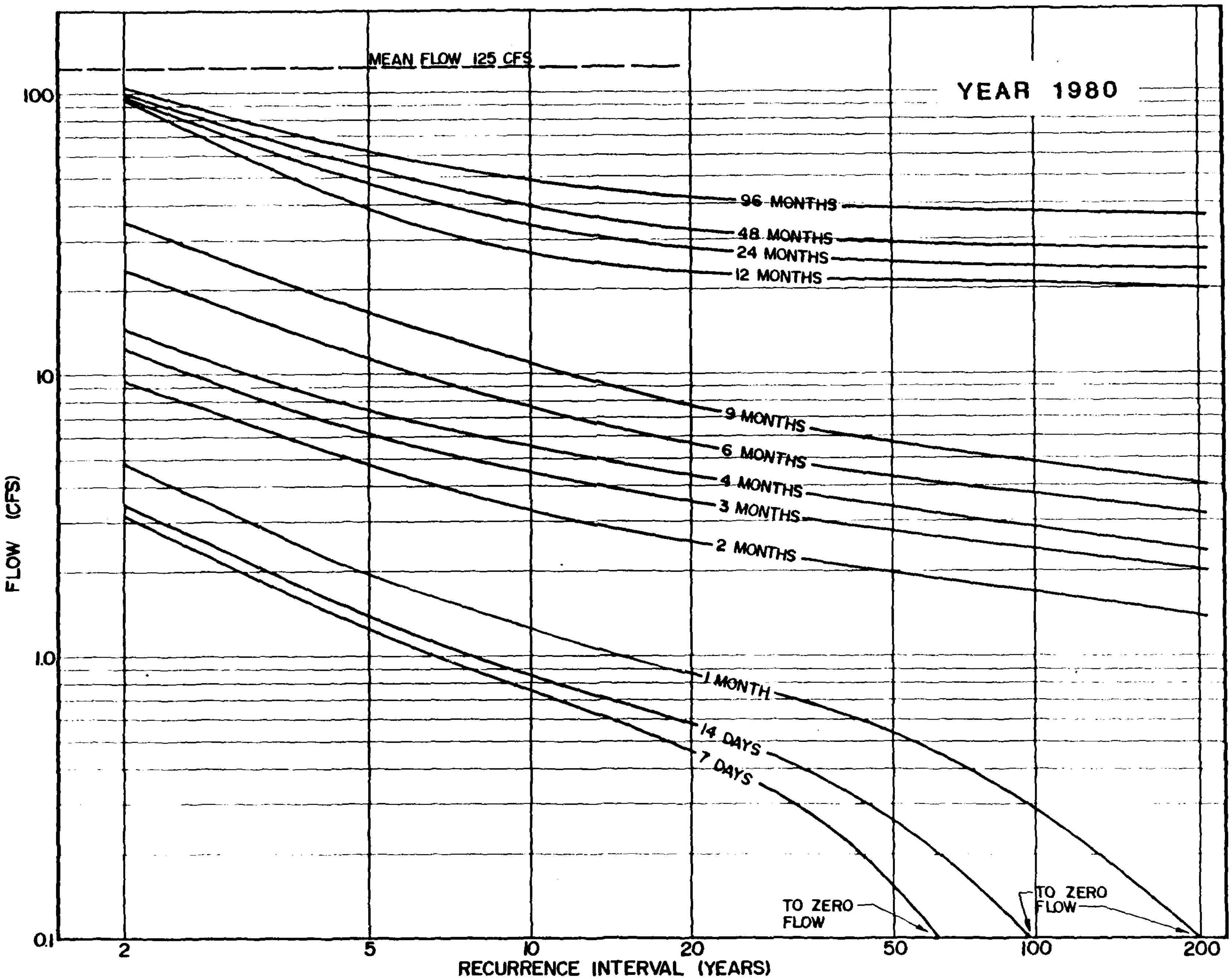


FIGURE 54: Low-Flow Frequency Curves, Buffalo River at Dilworth - Year 1980 Case

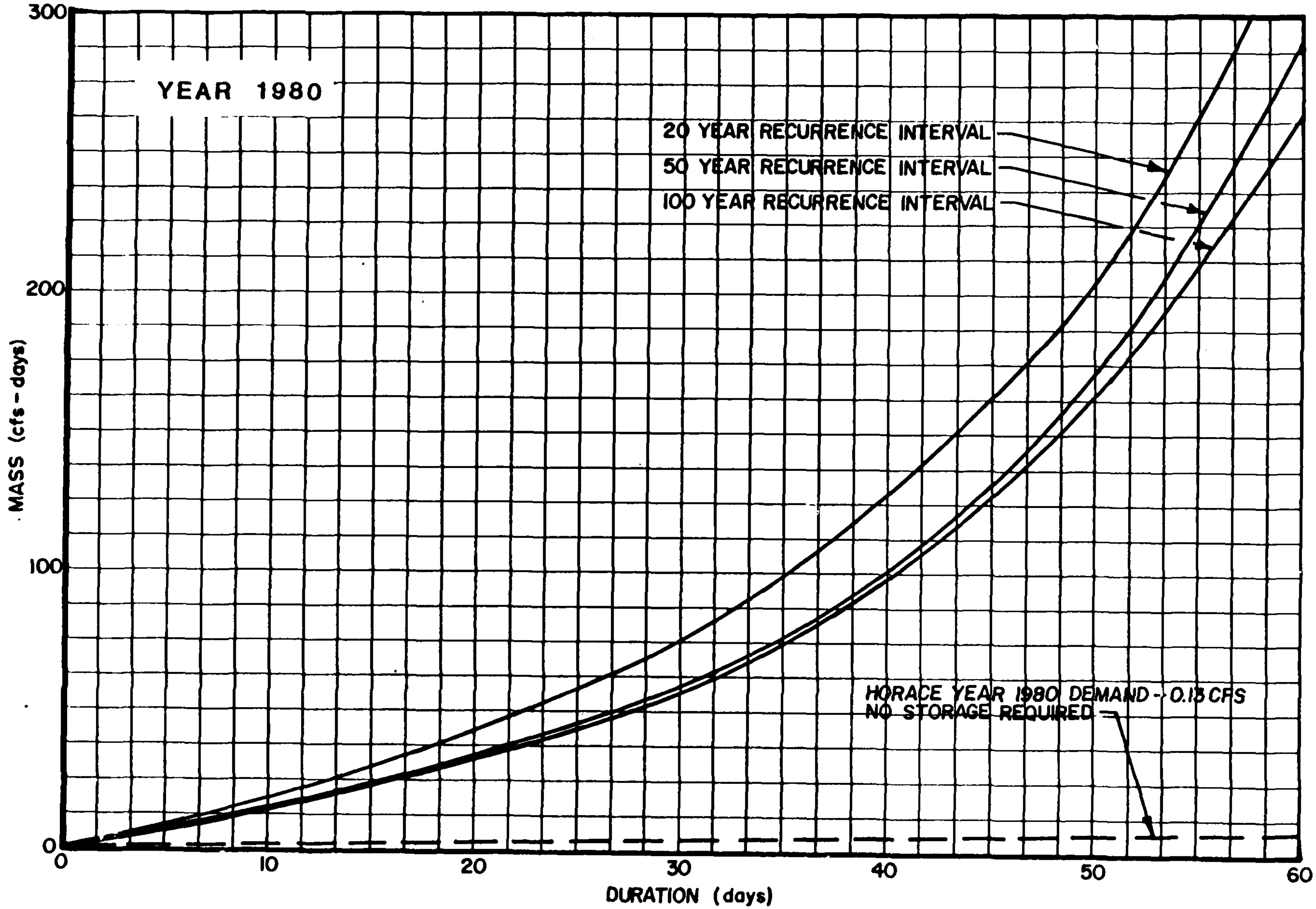
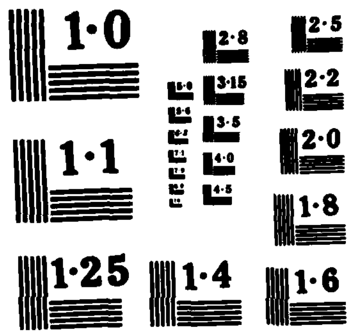


FIGURE 55: Mass Curves for the Sheyenne River at Horace (Alternatives 1-10)

AD-A157 283 FARGO-MOORHEAD URBAN STUDY WATER SUPPLY APPENDIX VOLUME 1 PHASE 1 PART 1..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT MAY 85 3/5

UNCLASSIFIED F/G 13/2 NL


1·0
2·8
2·5
3·15
2·2
3·5
2·0
1·1
4·0
4·5
1·8
1·25
1·4
1·6

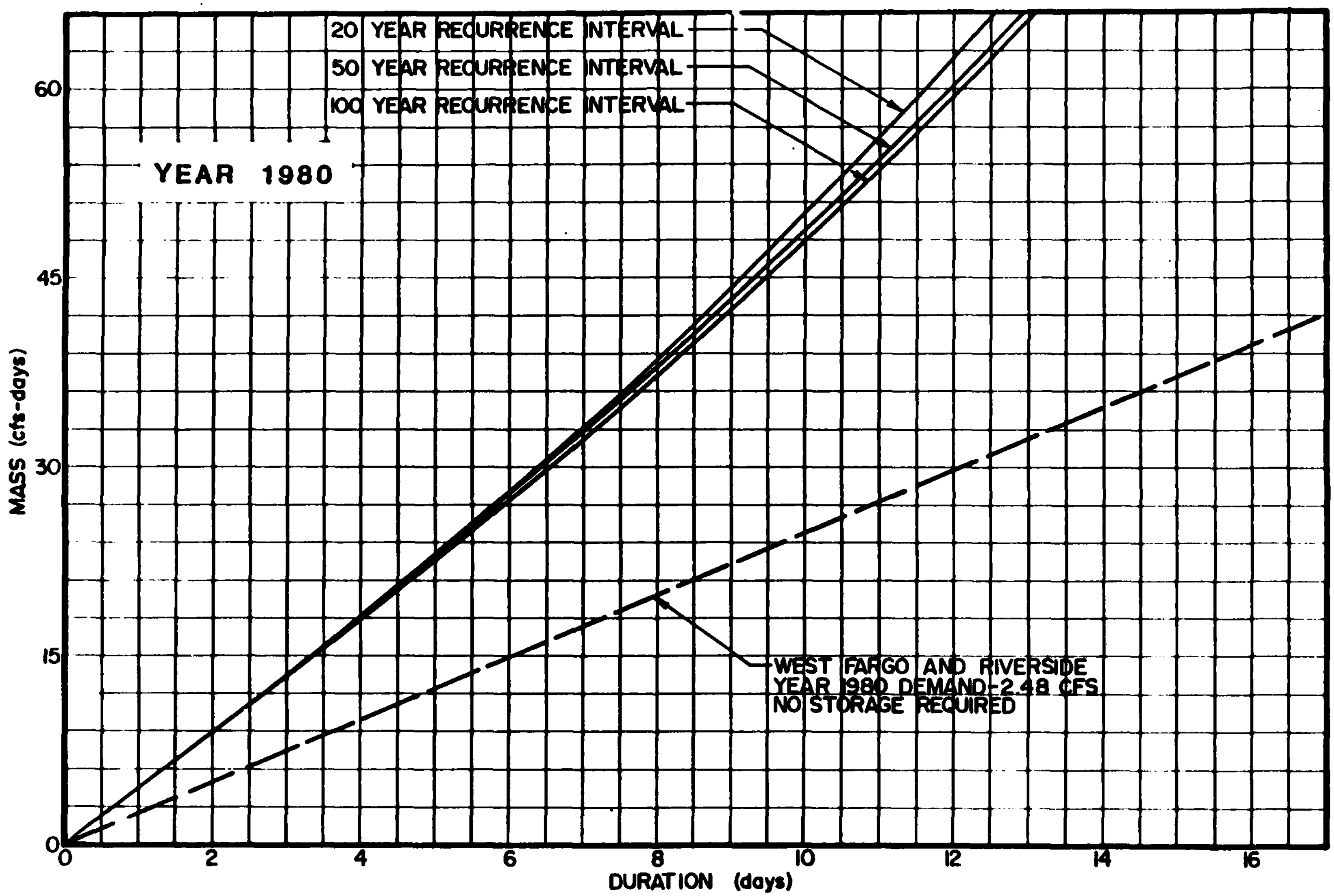


FIGURE 56: Mass Curves for the Sheyenne River at West Fargo (Alternatives 1-3)

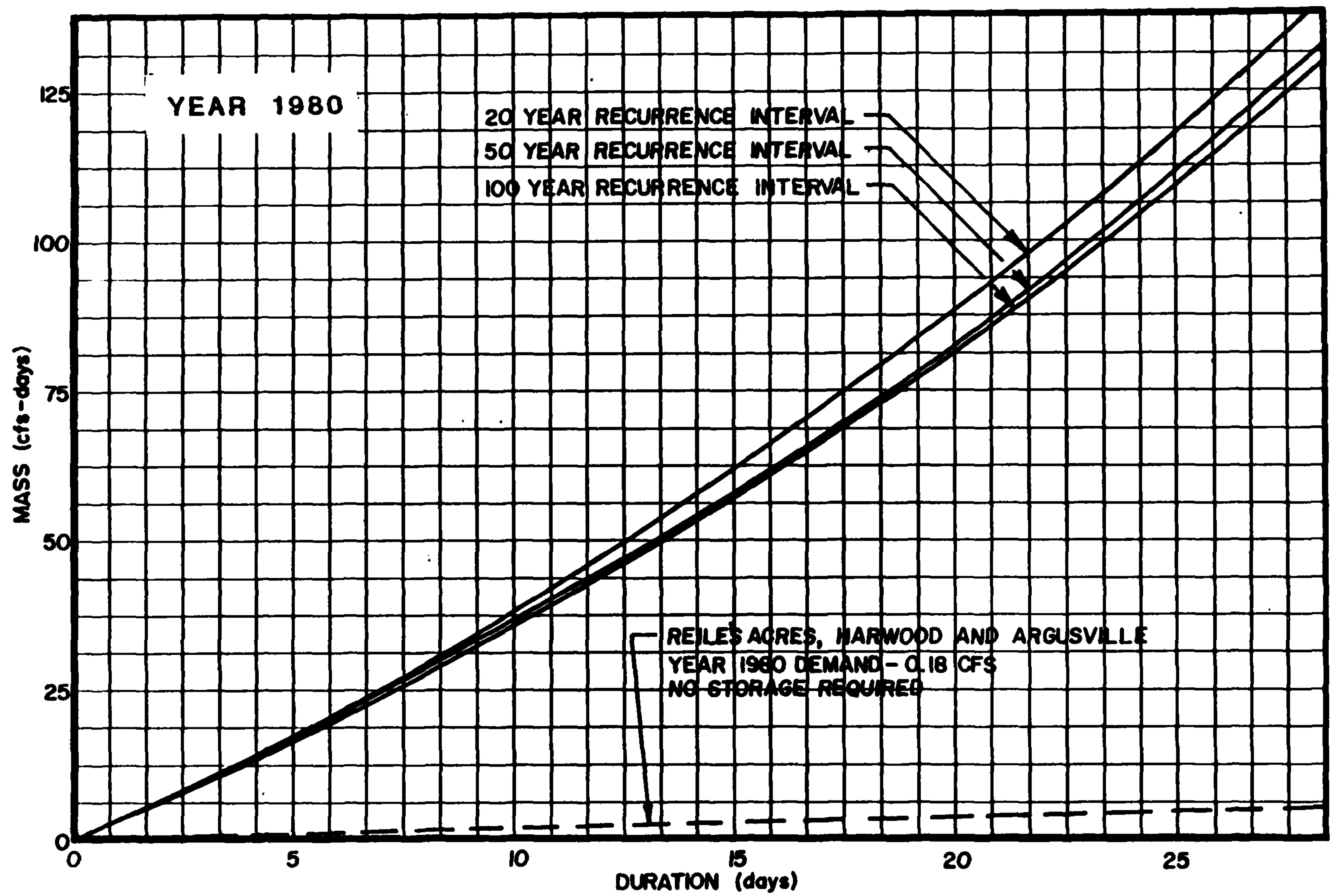


FIGURE 57: Mass Curves for the Sheyenne River at Reile's Acres (Alternatives 1-10)

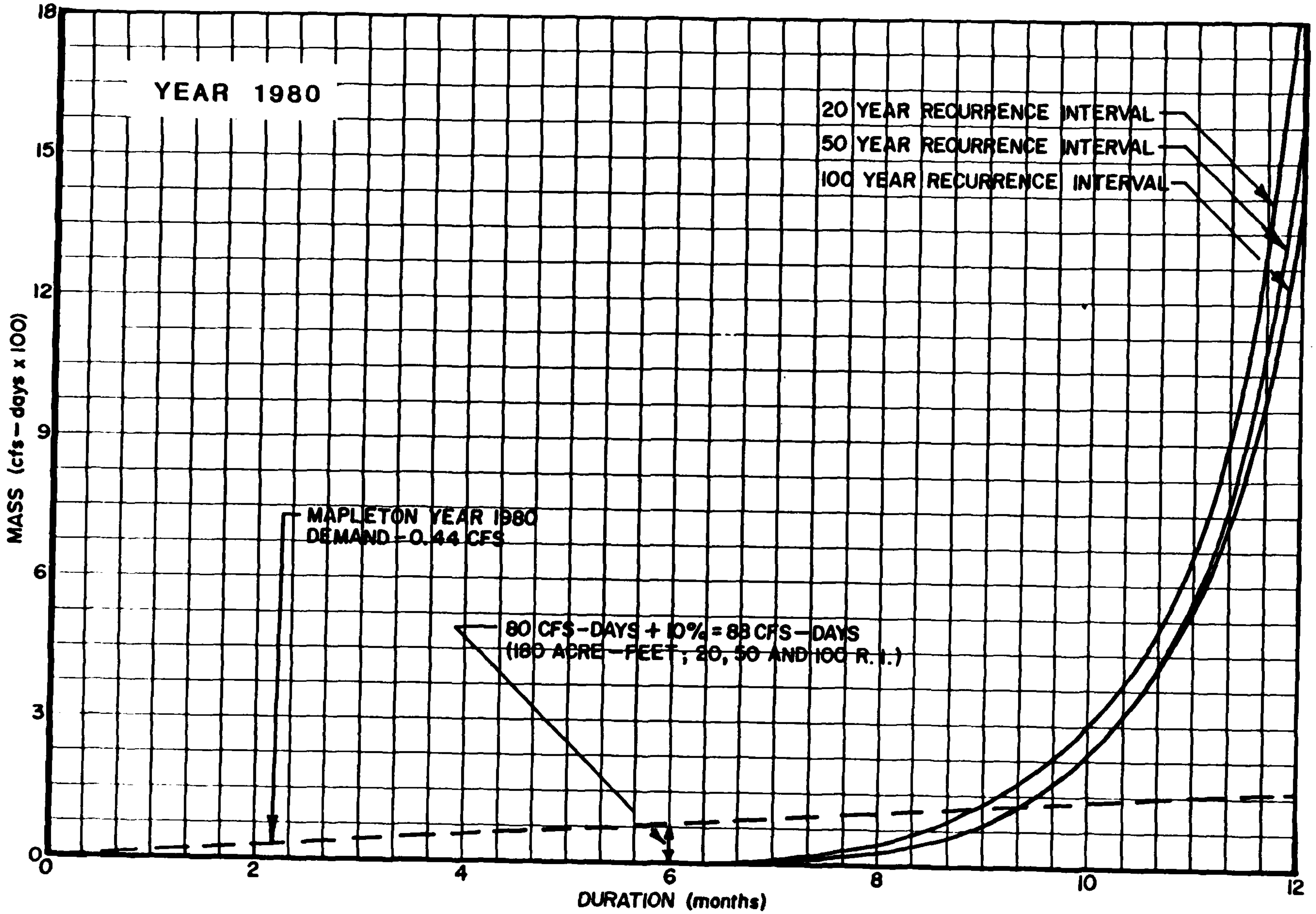


FIGURE 58: Mass Curves for the Maple River at Mapleton (Alternatives 1-6)

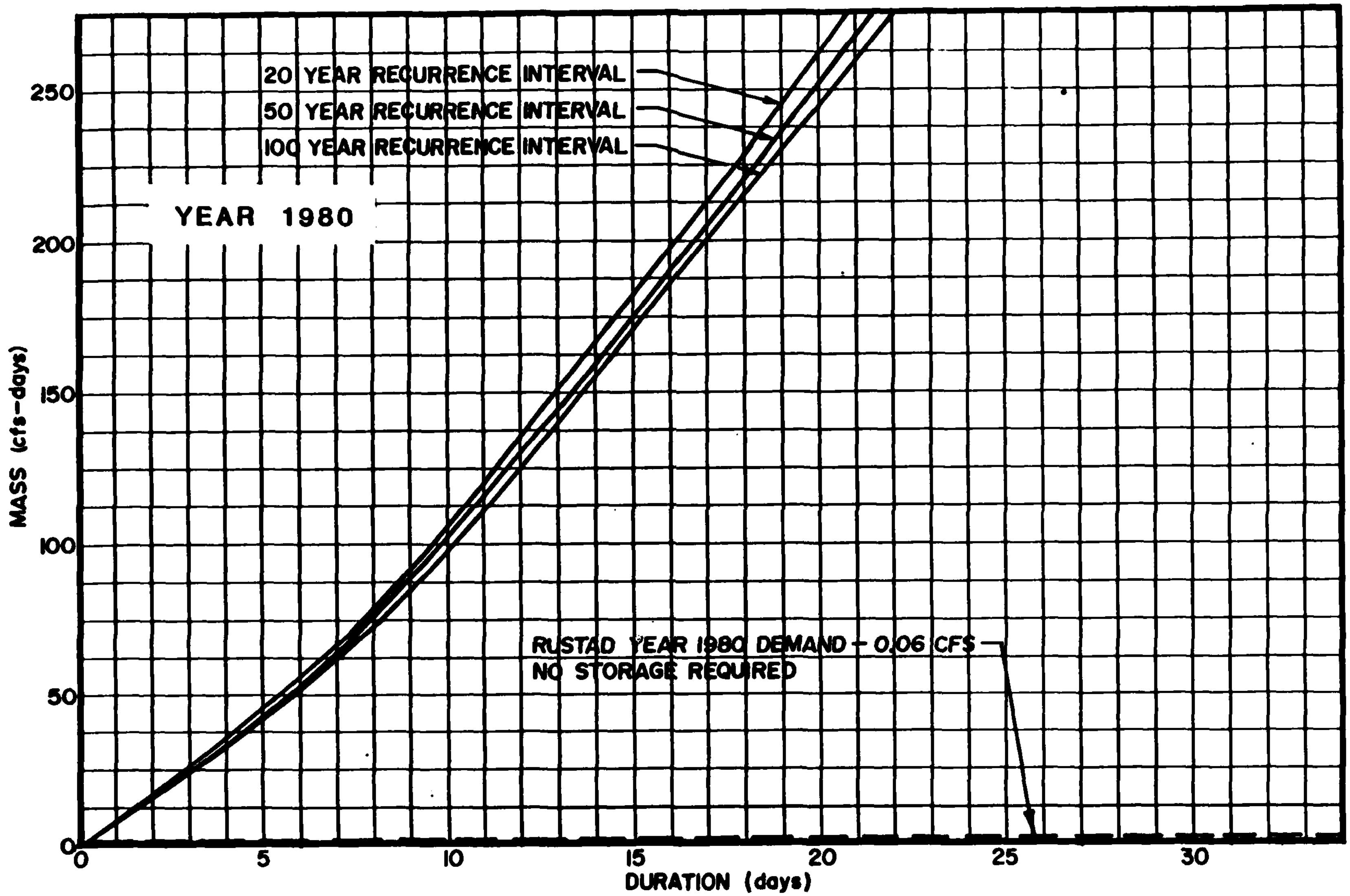


FIGURE 59: Mass Curves for the Red River at Rustad (Alternatives 1-10)

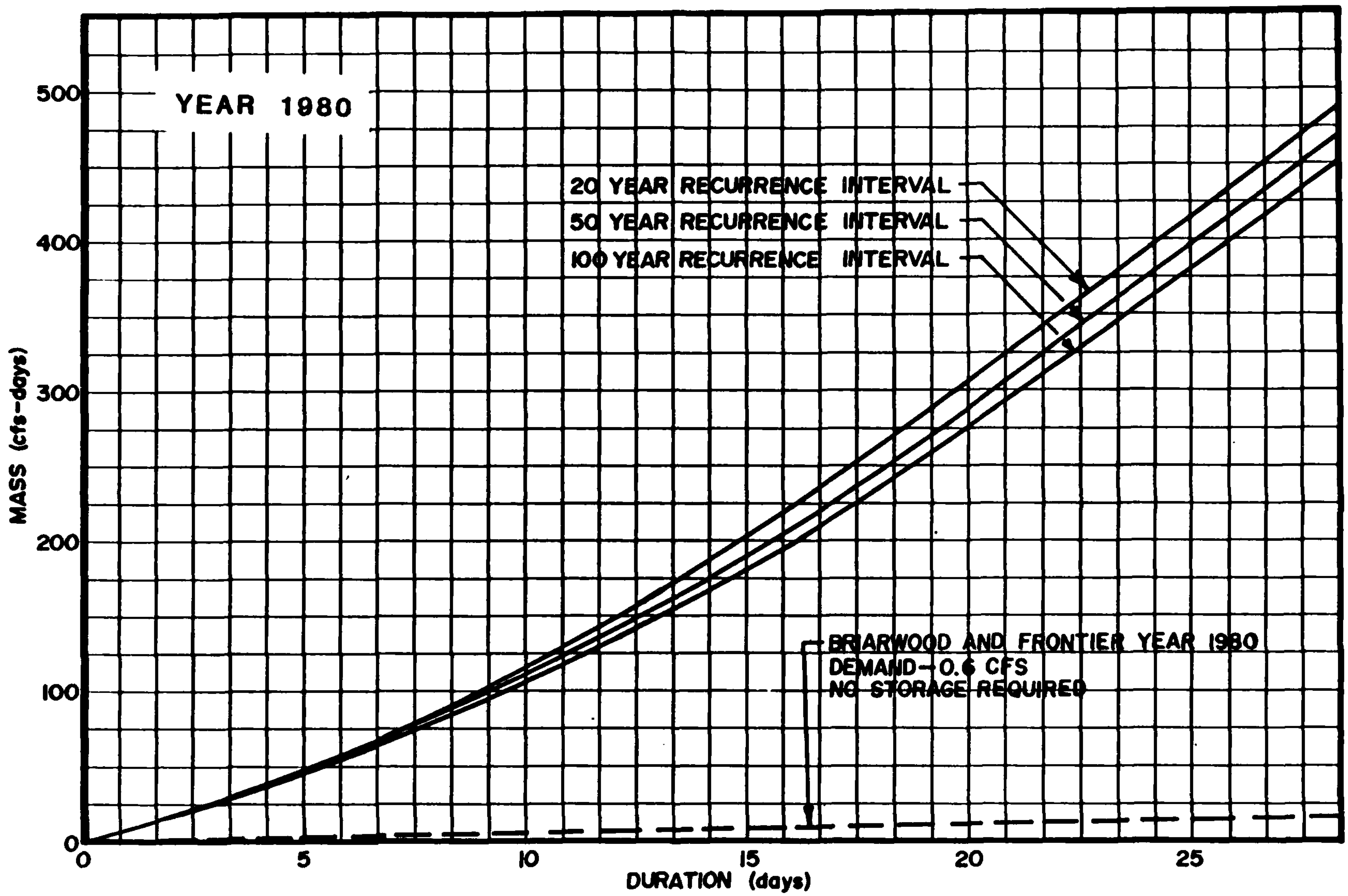


FIGURE 60: Mass Curves for the Red River at Briarwood (Alternatives 1-10)

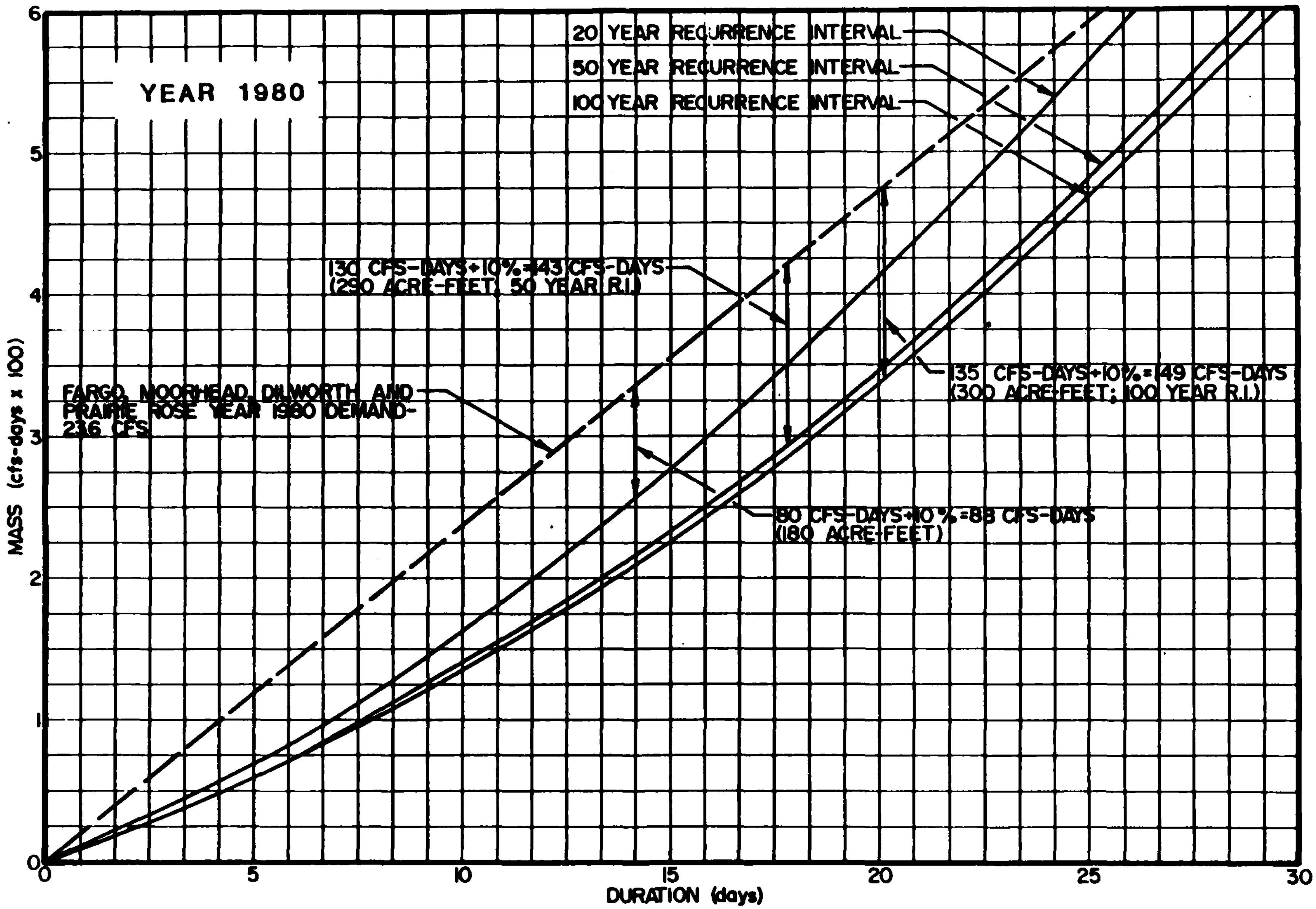


FIGURE 61: Mass Curves for the Red River at Fargo (Alternative 1)

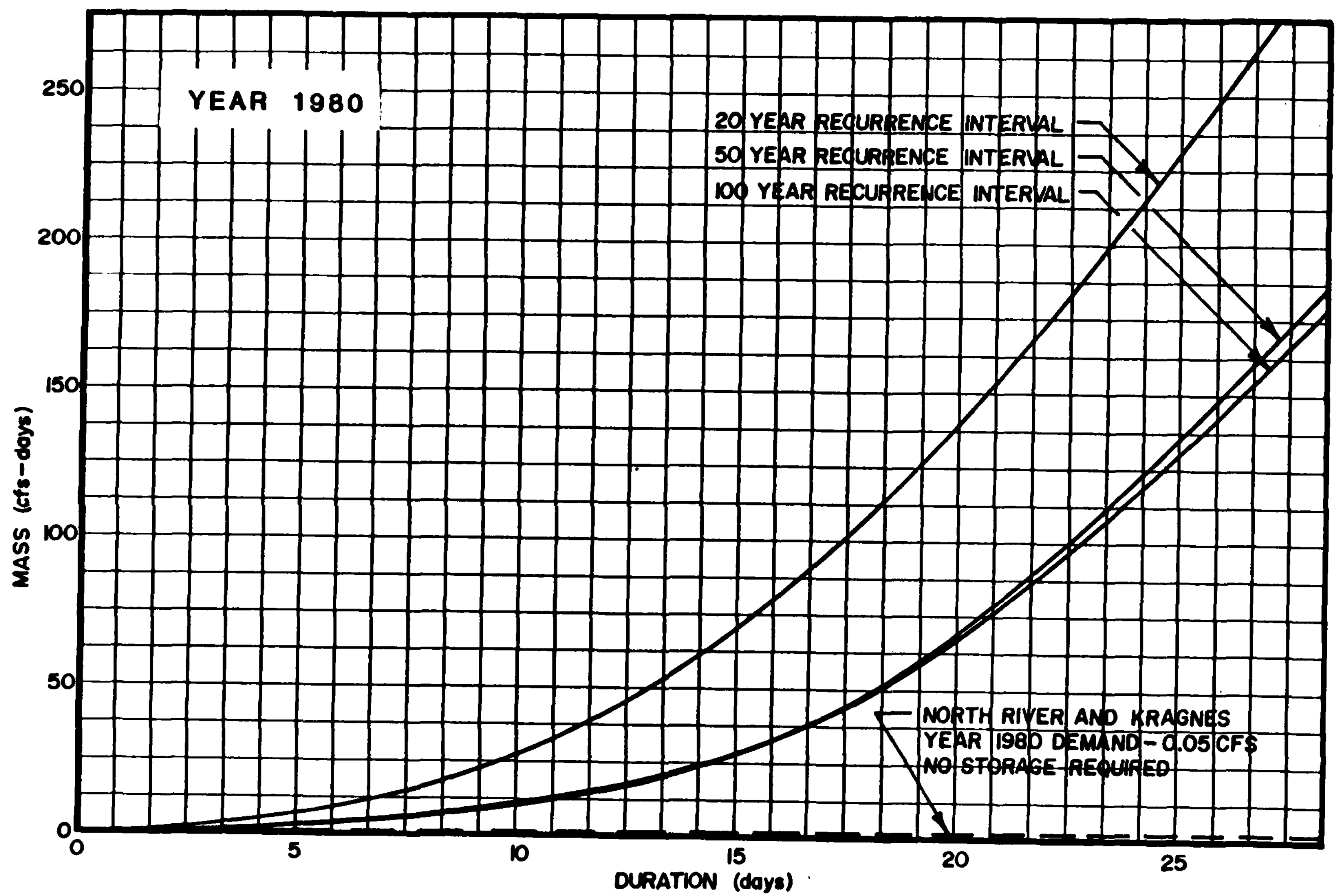


FIGURE 62: Mass Curves for the Red River at North River (Alternatives 1-10)

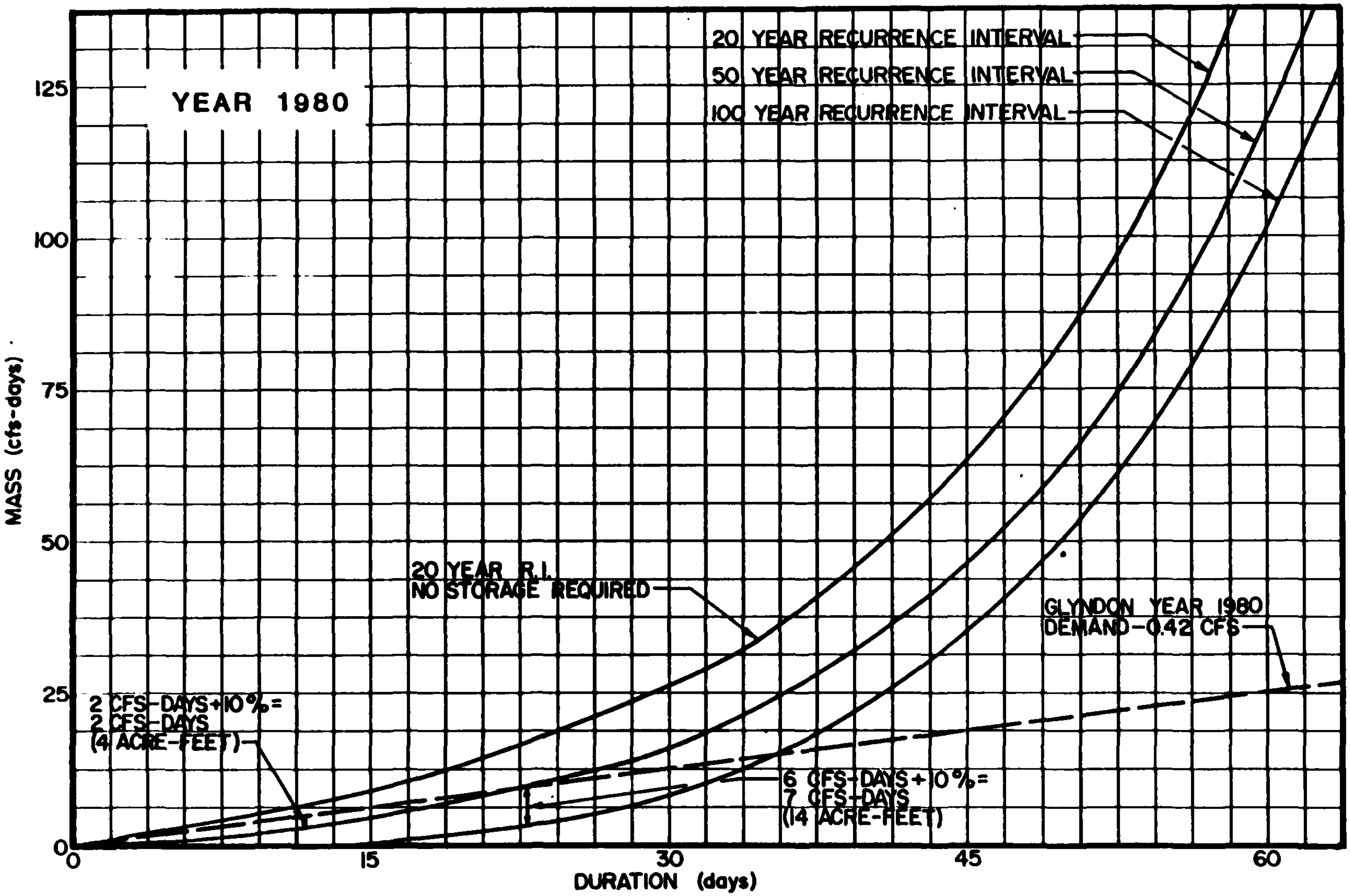


FIGURE 63: Mass Curves for the Buffalo River at Dilworth (Alternatives 1, 6 and 10)

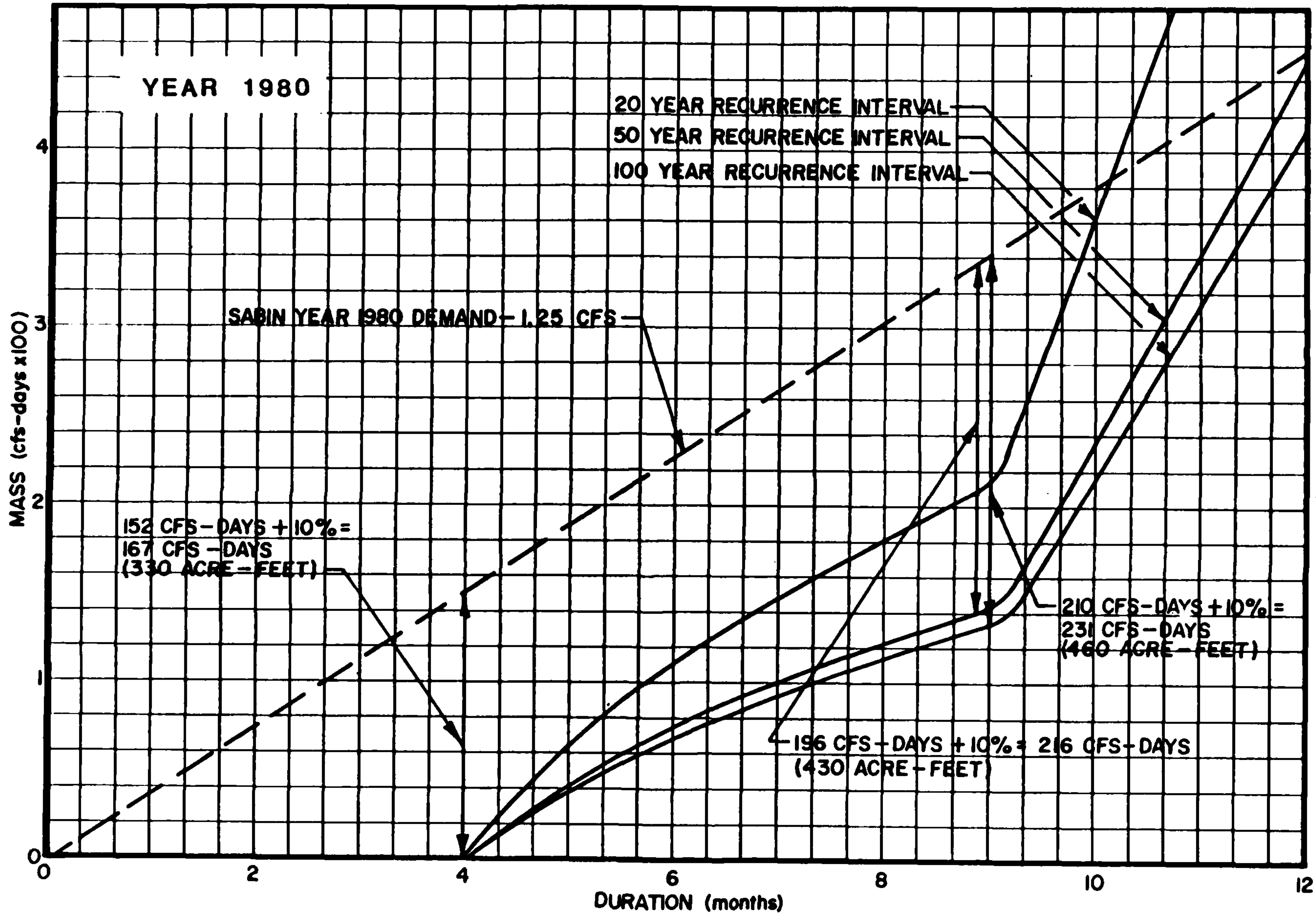


FIGURE 64: Mass Curves for the South Branch Buffalo River at Sabin (Alternatives 1-10)

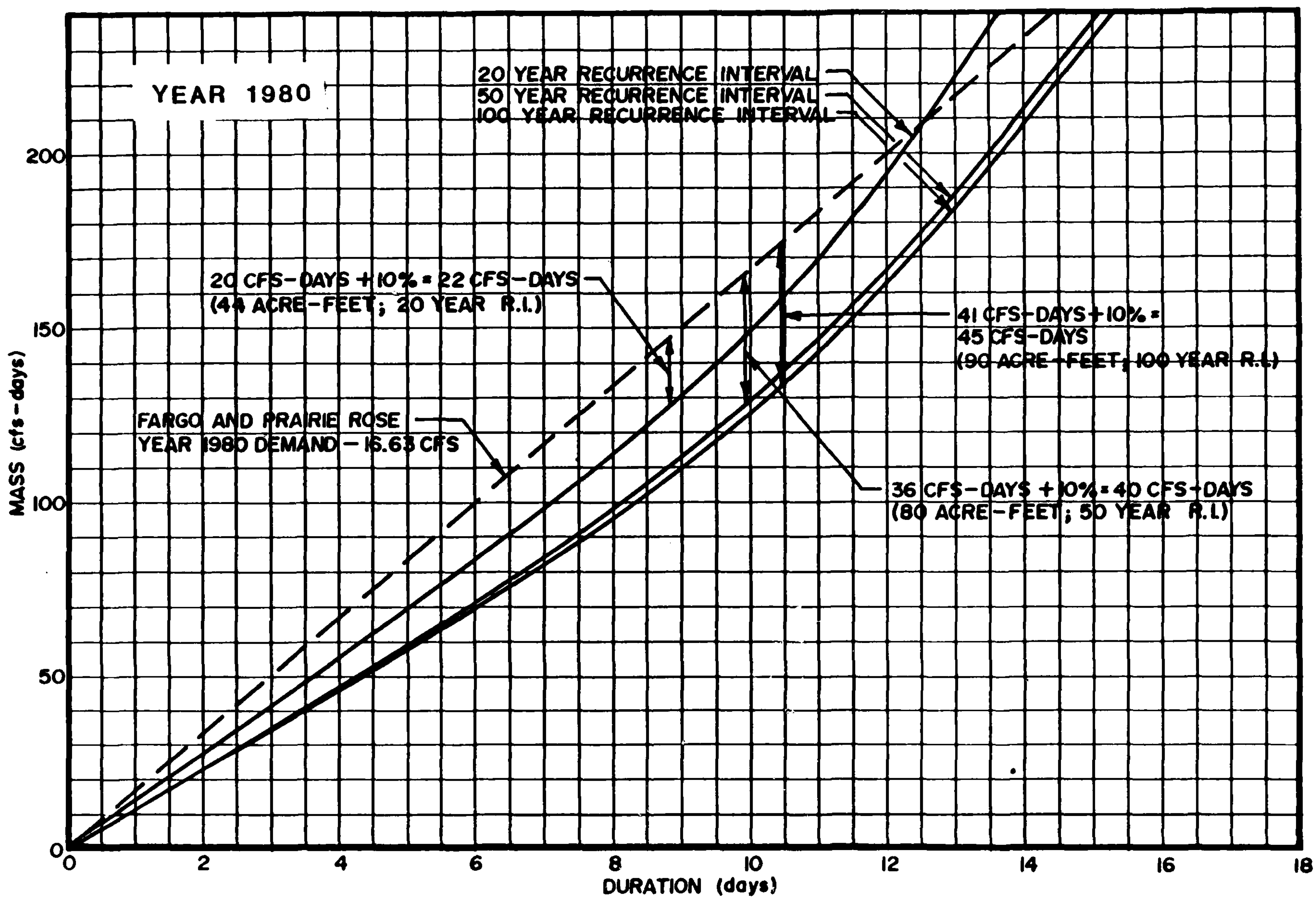


FIGURE 65: Mass Curves for the Red River at Fargo (Alternative 2)

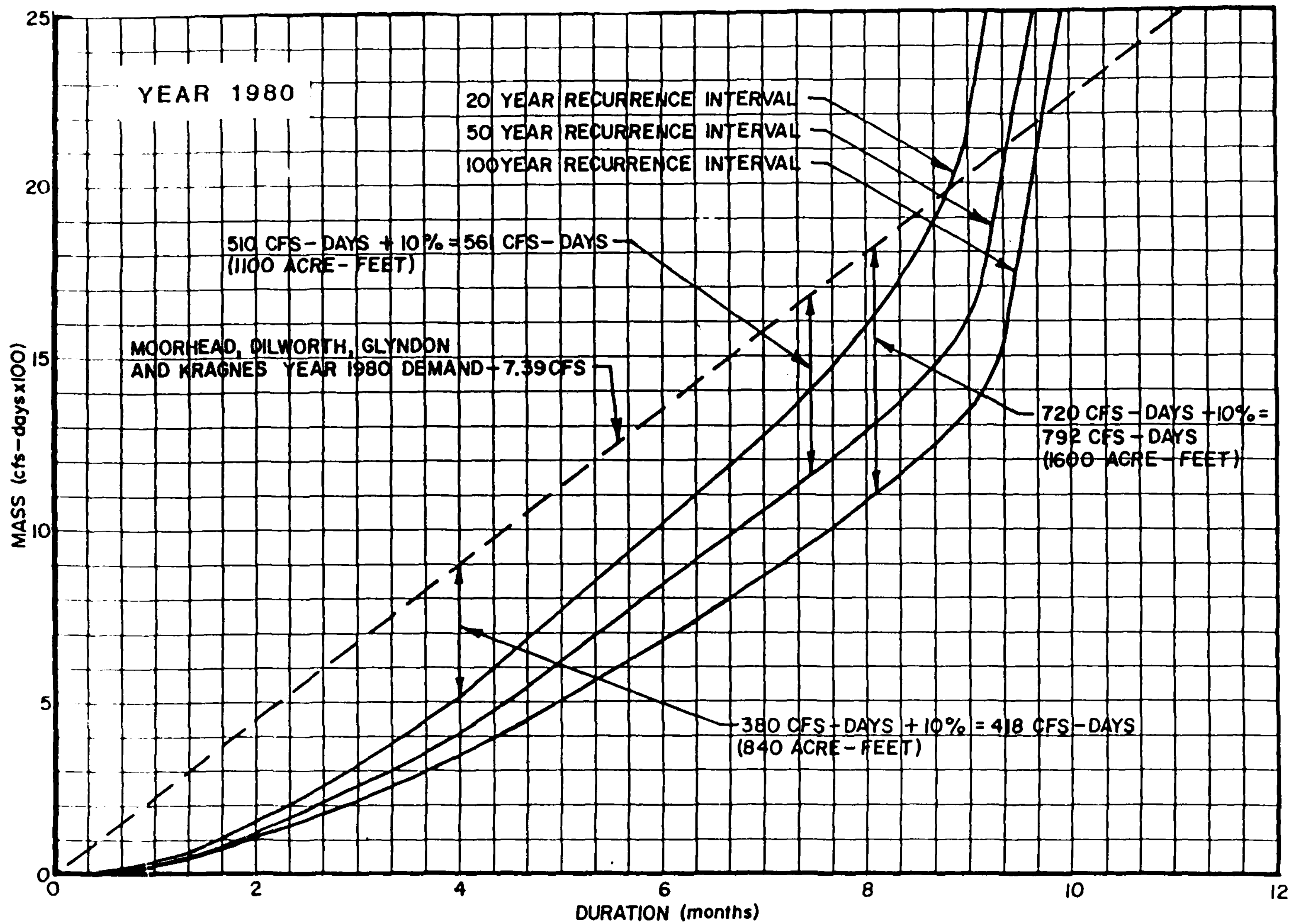


FIGURE 66: Mass Curves for the Buffalo River at Dilworth (Alternative 2)

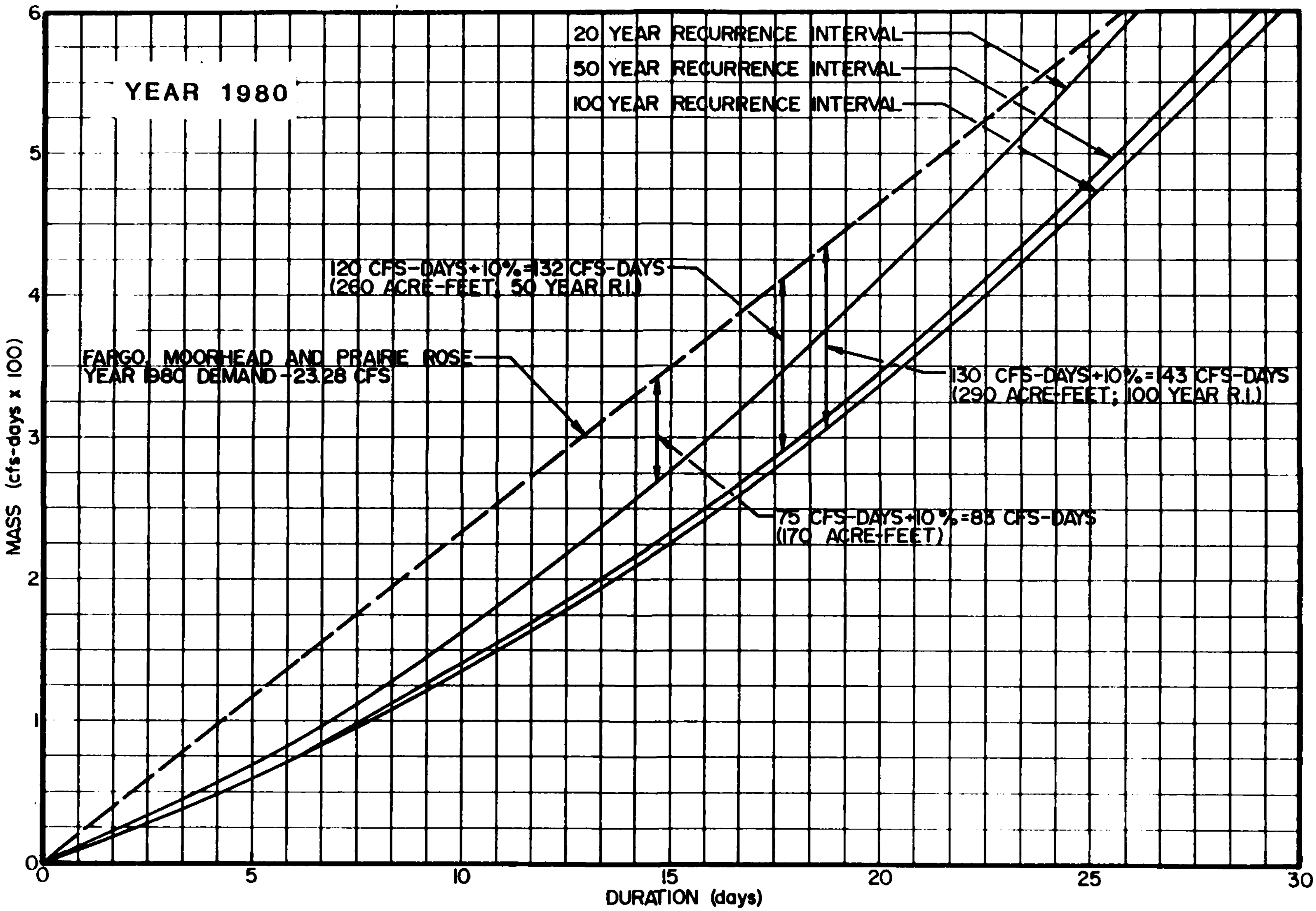


FIGURE 67: Mass Curves for the Red River at Fargo (Alternative 3)

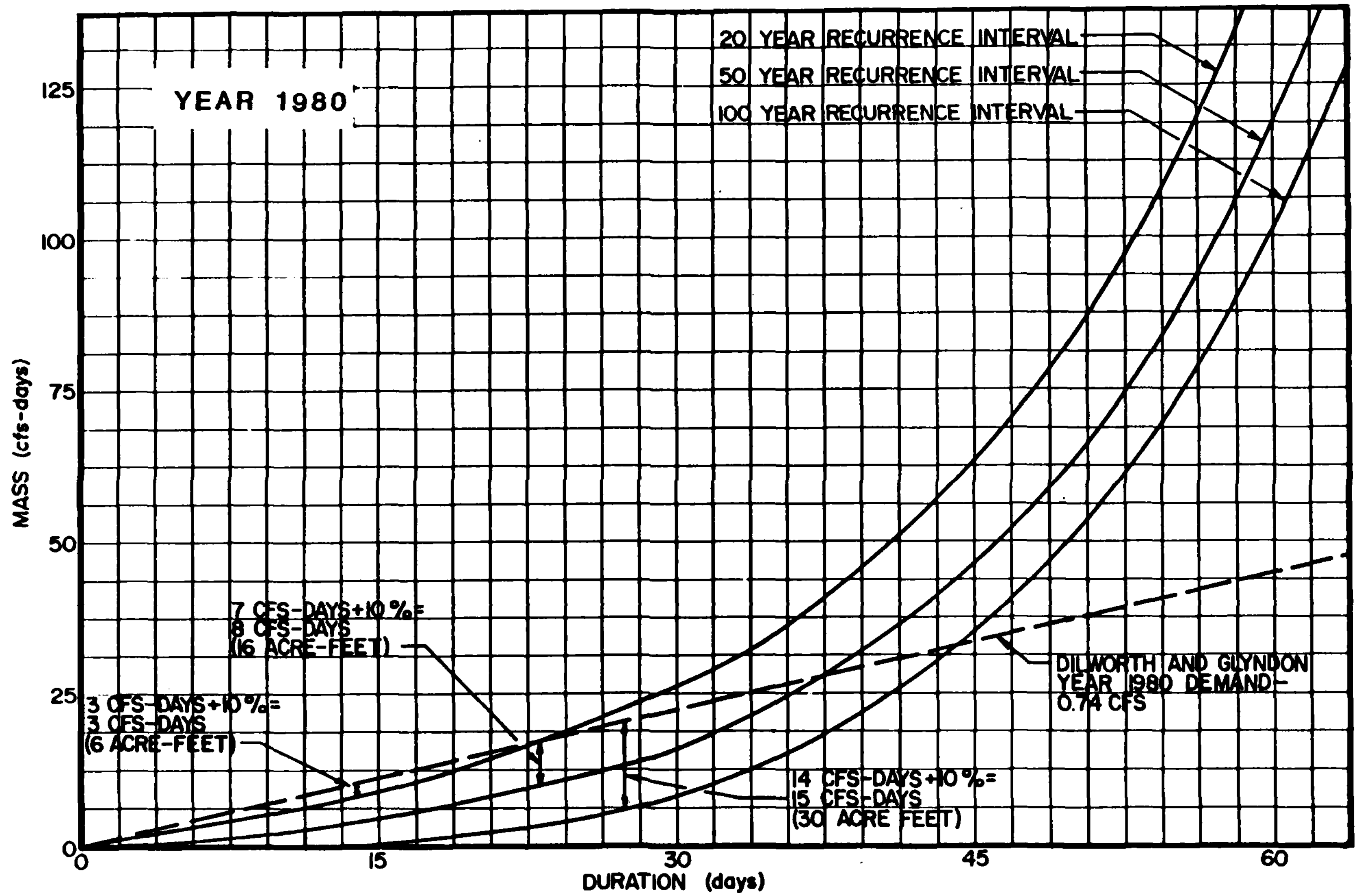


FIGURE 68: Mass Curves for the Buffalo River at Dilworth (Alternatives 3, 4 and 8)

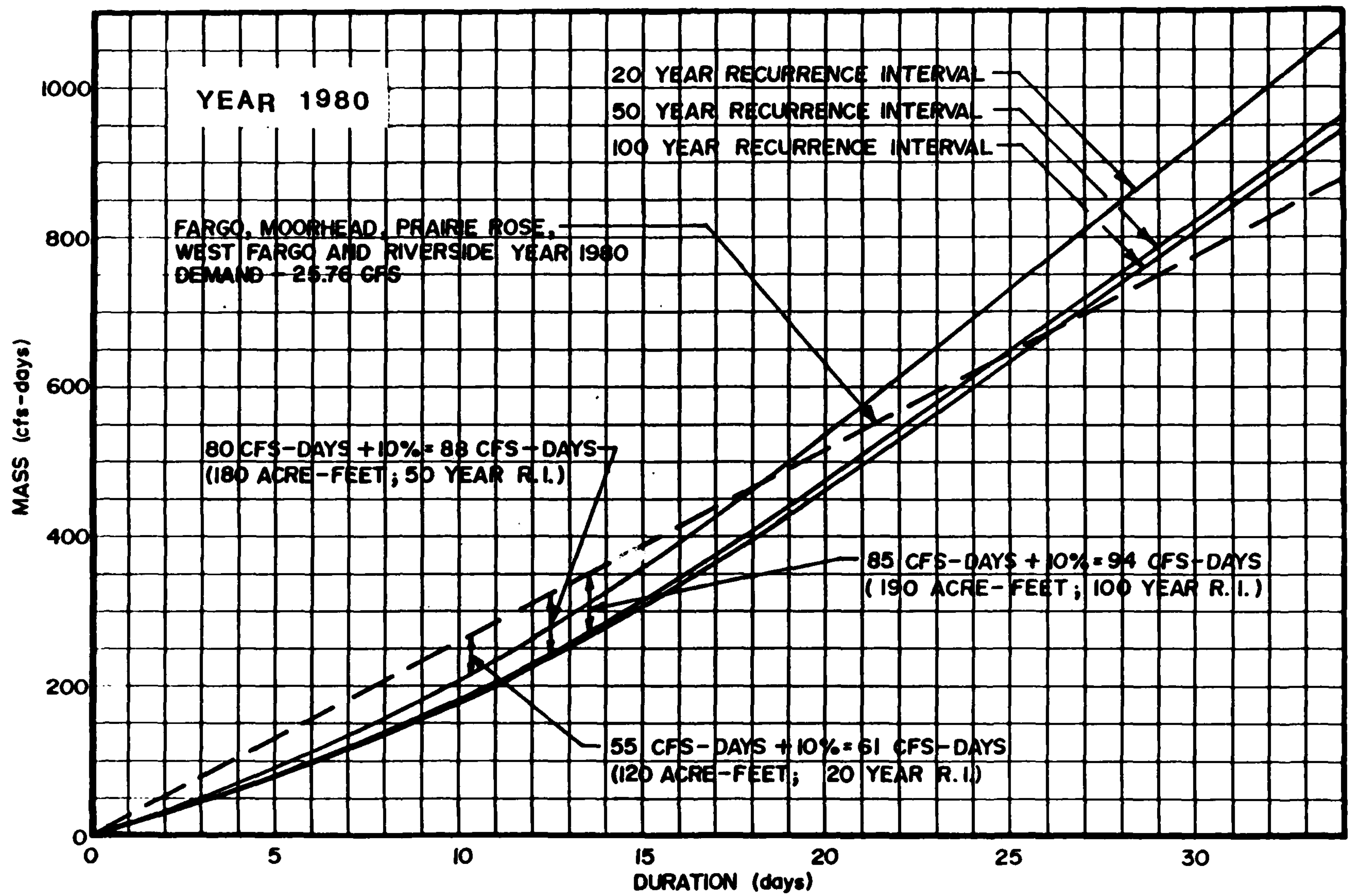


FIGURE 69: Mass Curves for the Sum of the Red River at Fargo and Sheyenne River at West Fargo (Alternative 4)

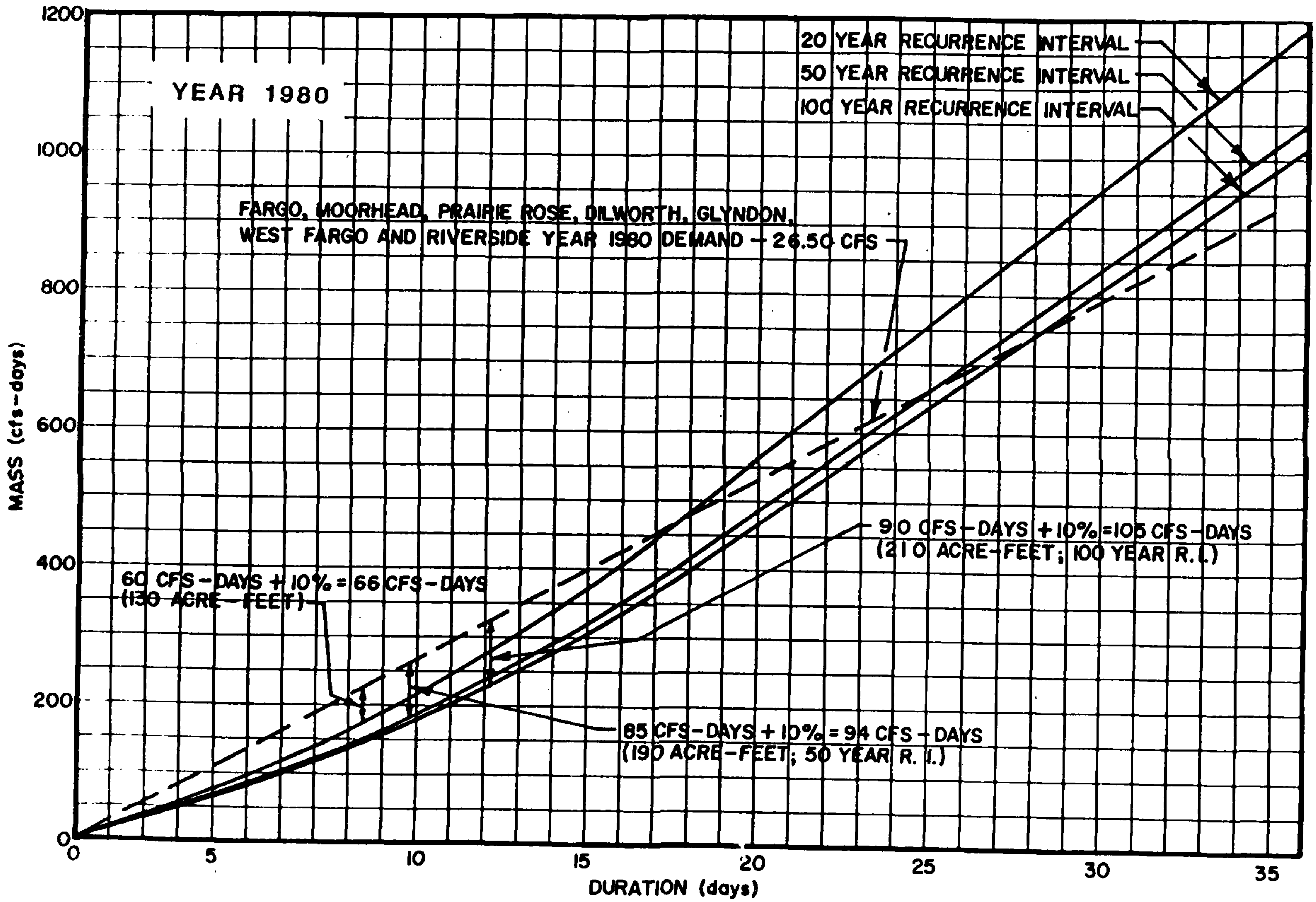


FIGURE 70: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Buffalo River (Alternative 5)

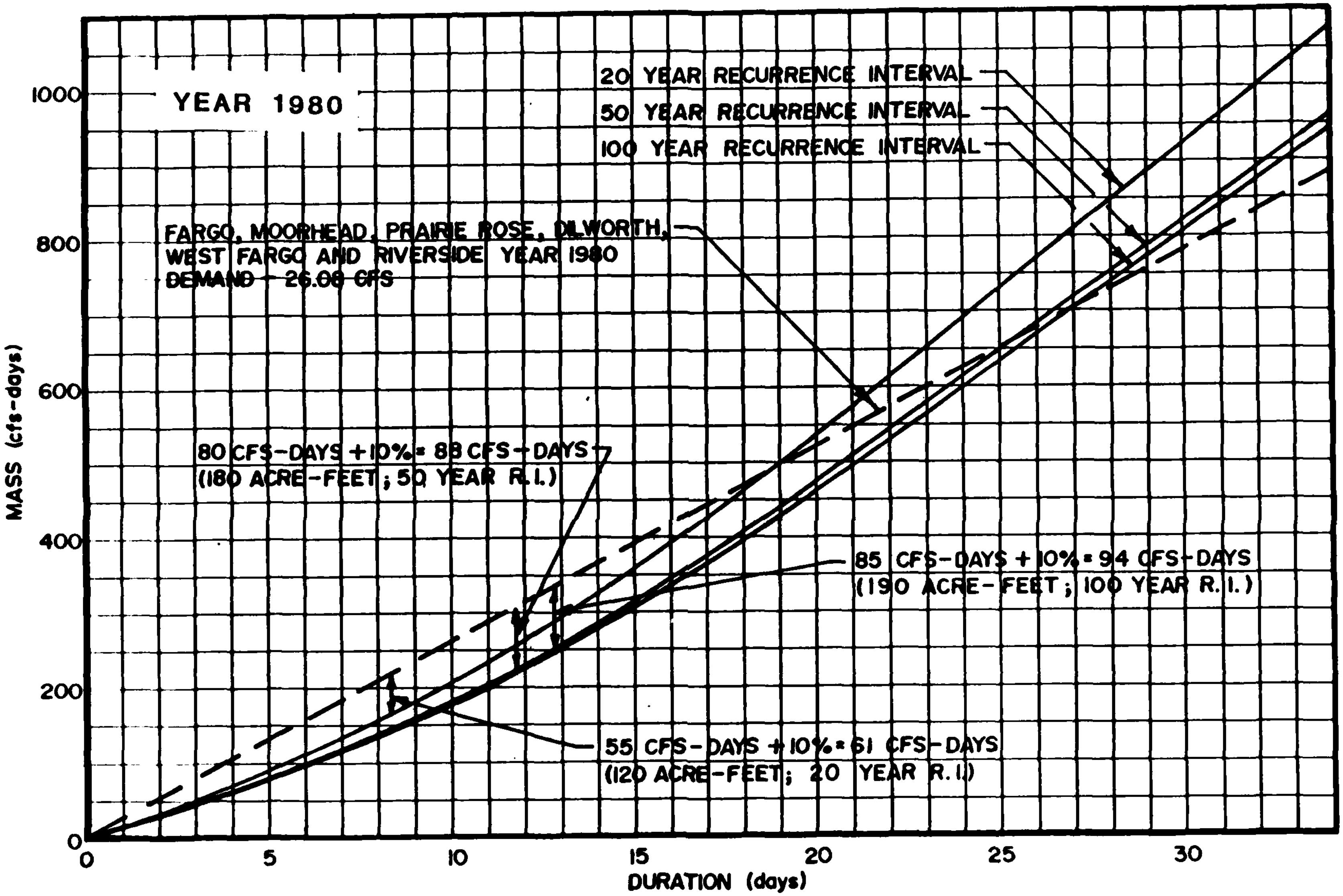


FIGURE 71: Mass Curves for the Sum of the Red River at Fargo and Sheyenne River at West Fargo (Alternative 6)

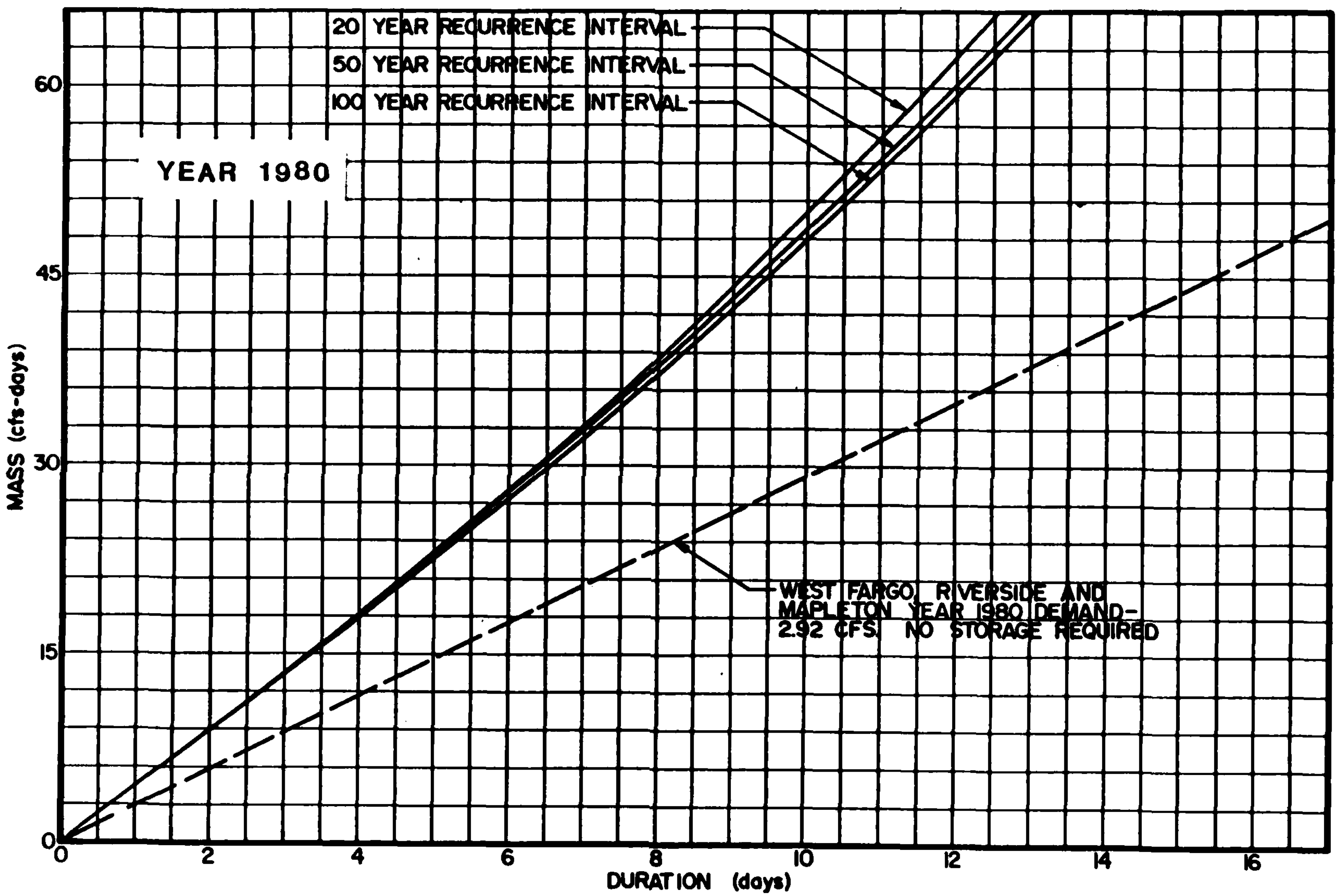


FIGURE 72: Mass Curves for the Sum of the Sheyenne River at West Fargo and Maple River (Alternative 7)

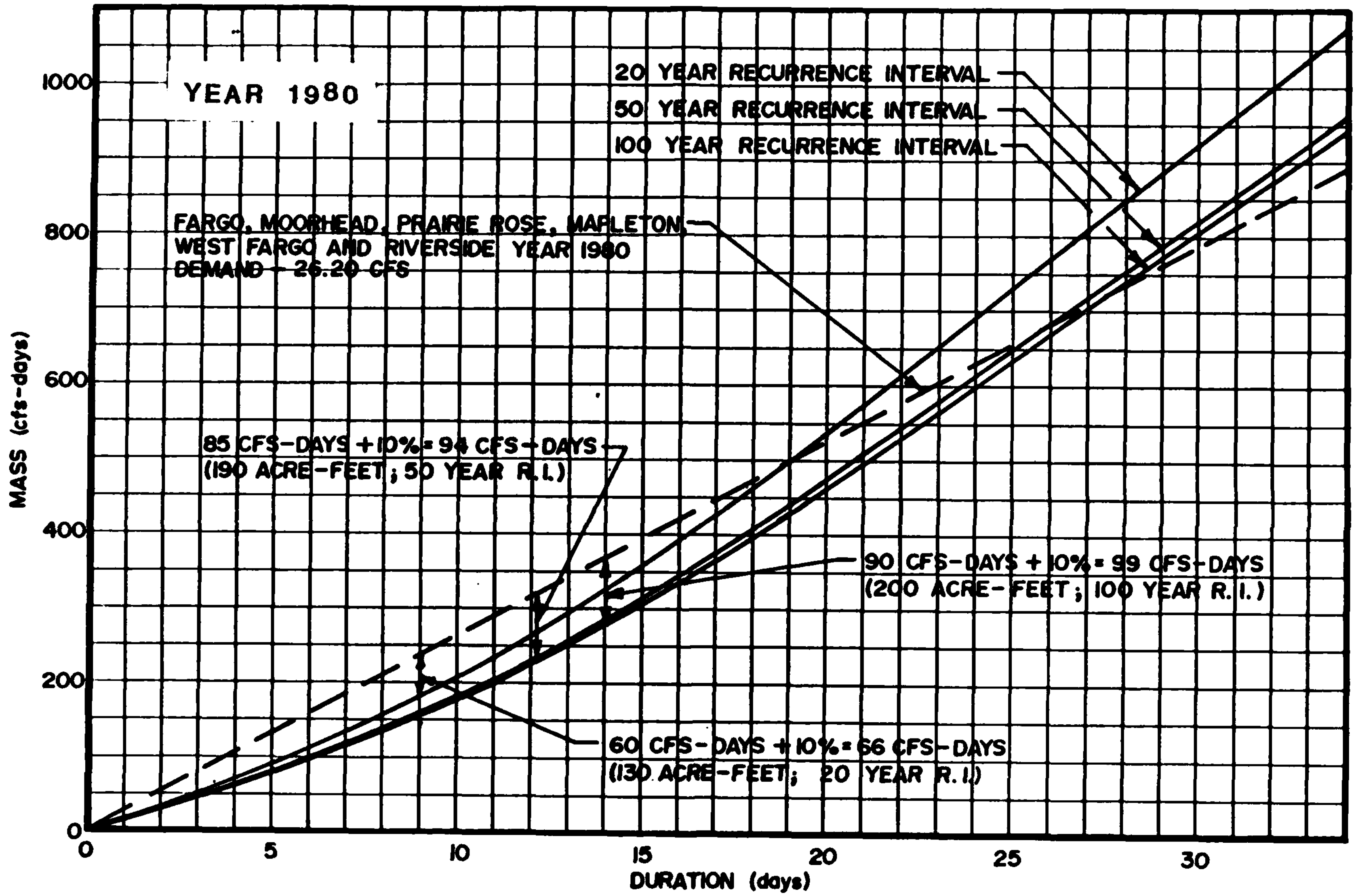


FIGURE 73: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Maple River (Alternative 8)

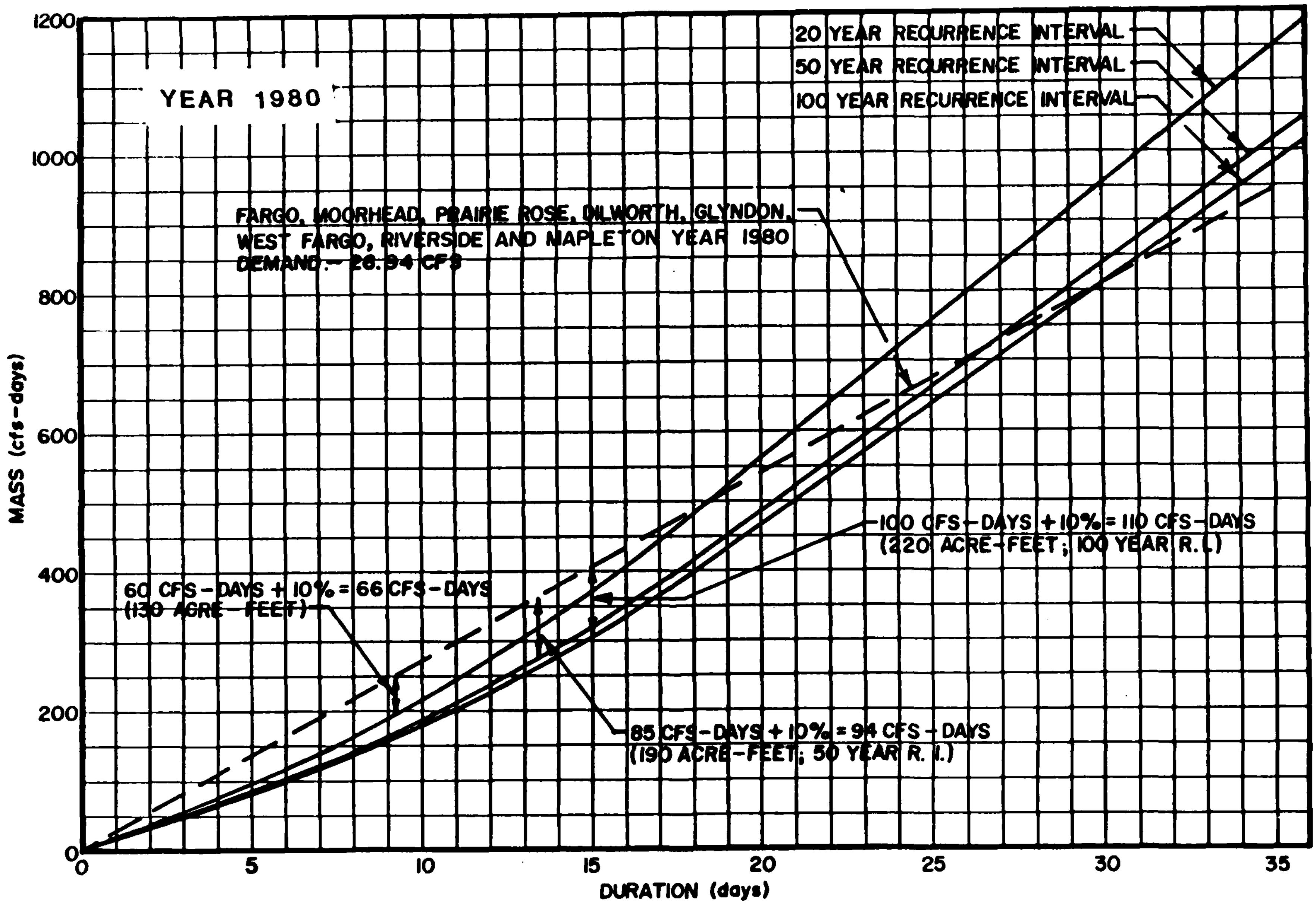


FIGURE 74: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Buffalo and Maple Rivers (Alternative 9)

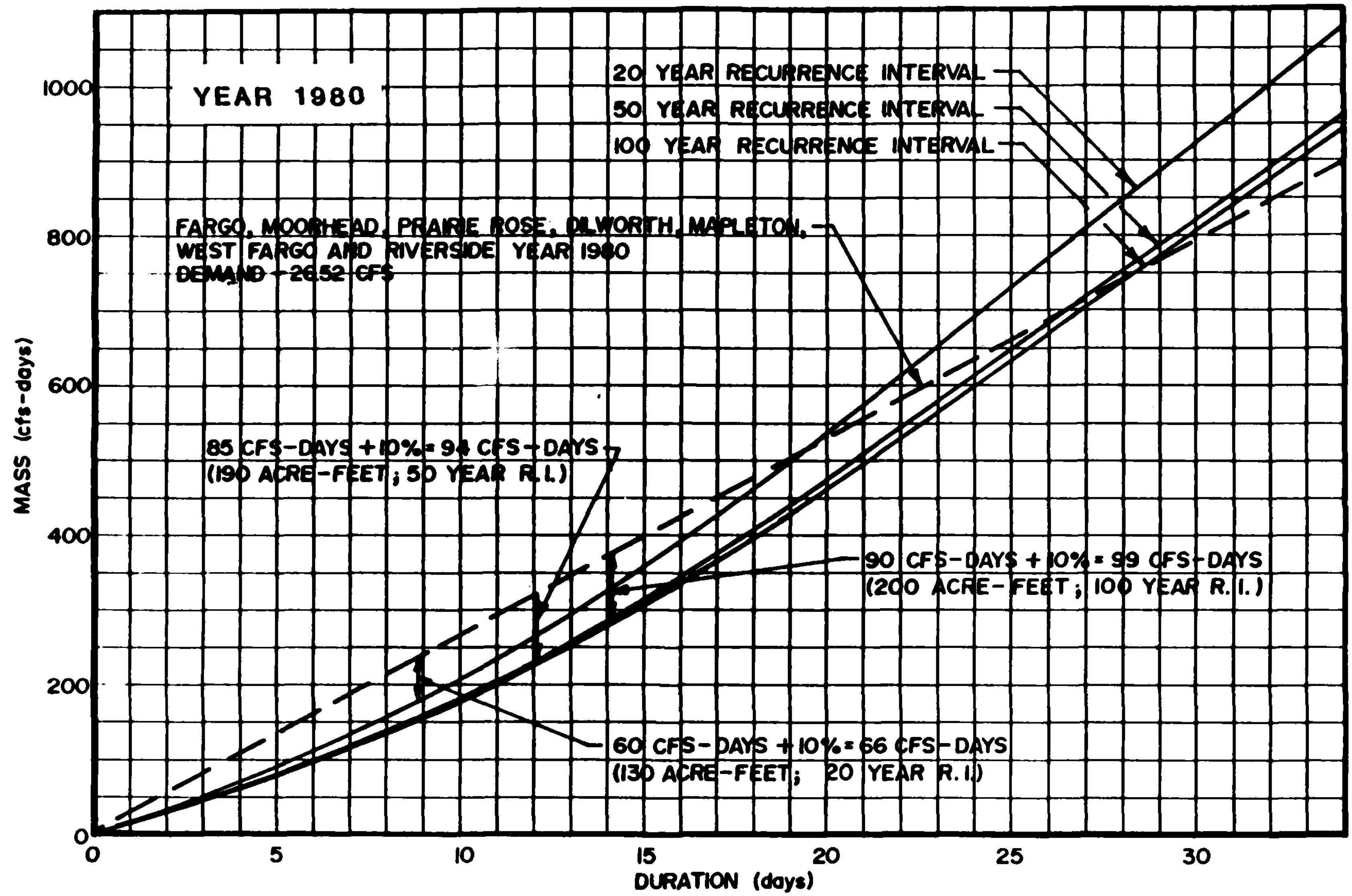


FIGURE 75: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo and Maple River (Alternative 10)

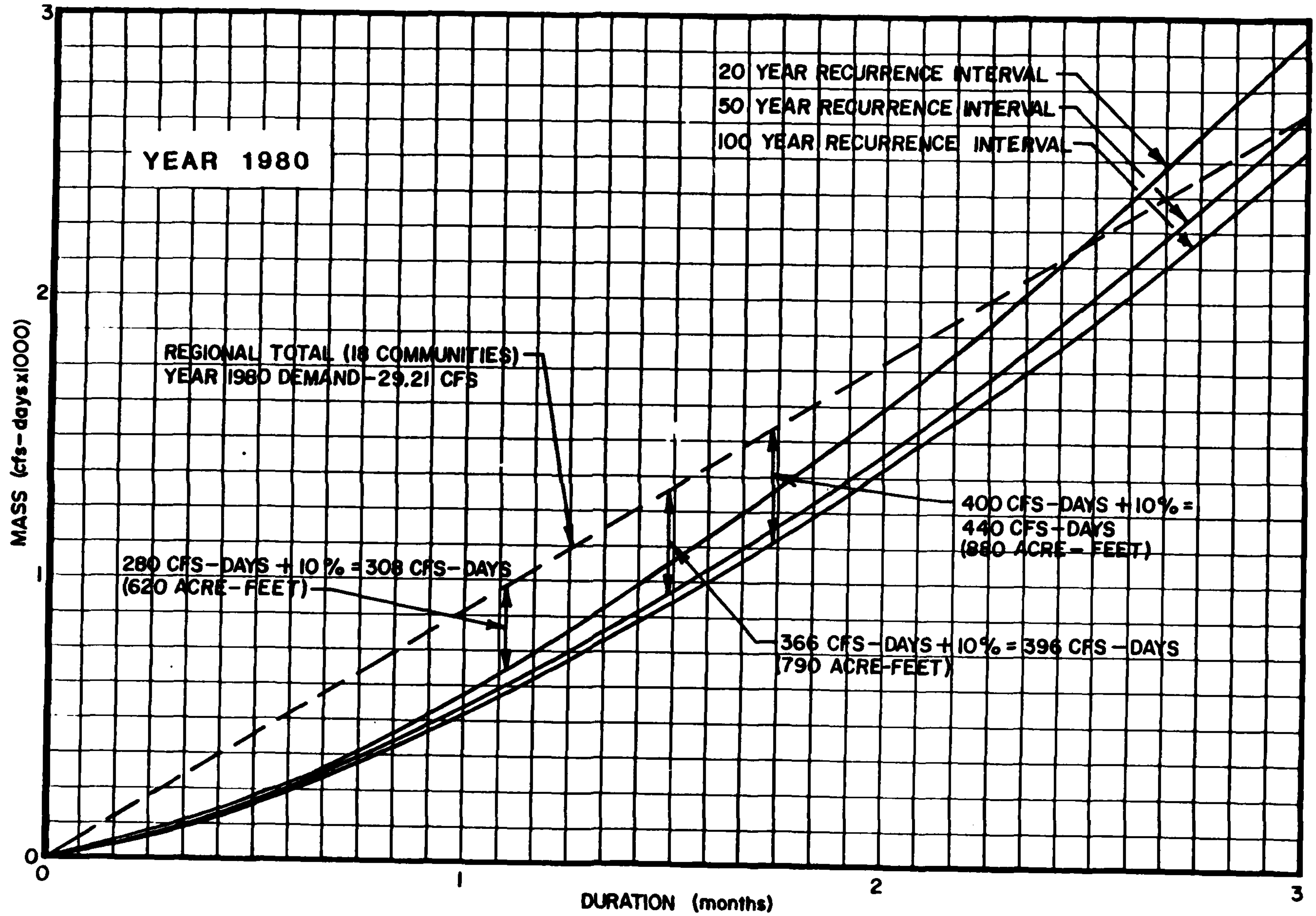


FIGURE 76: Mass Curves for the Sum of the Red River at Rustad, Sheyenne River at Horace, and Buffalo and Maple Rivers (Alternative 11)

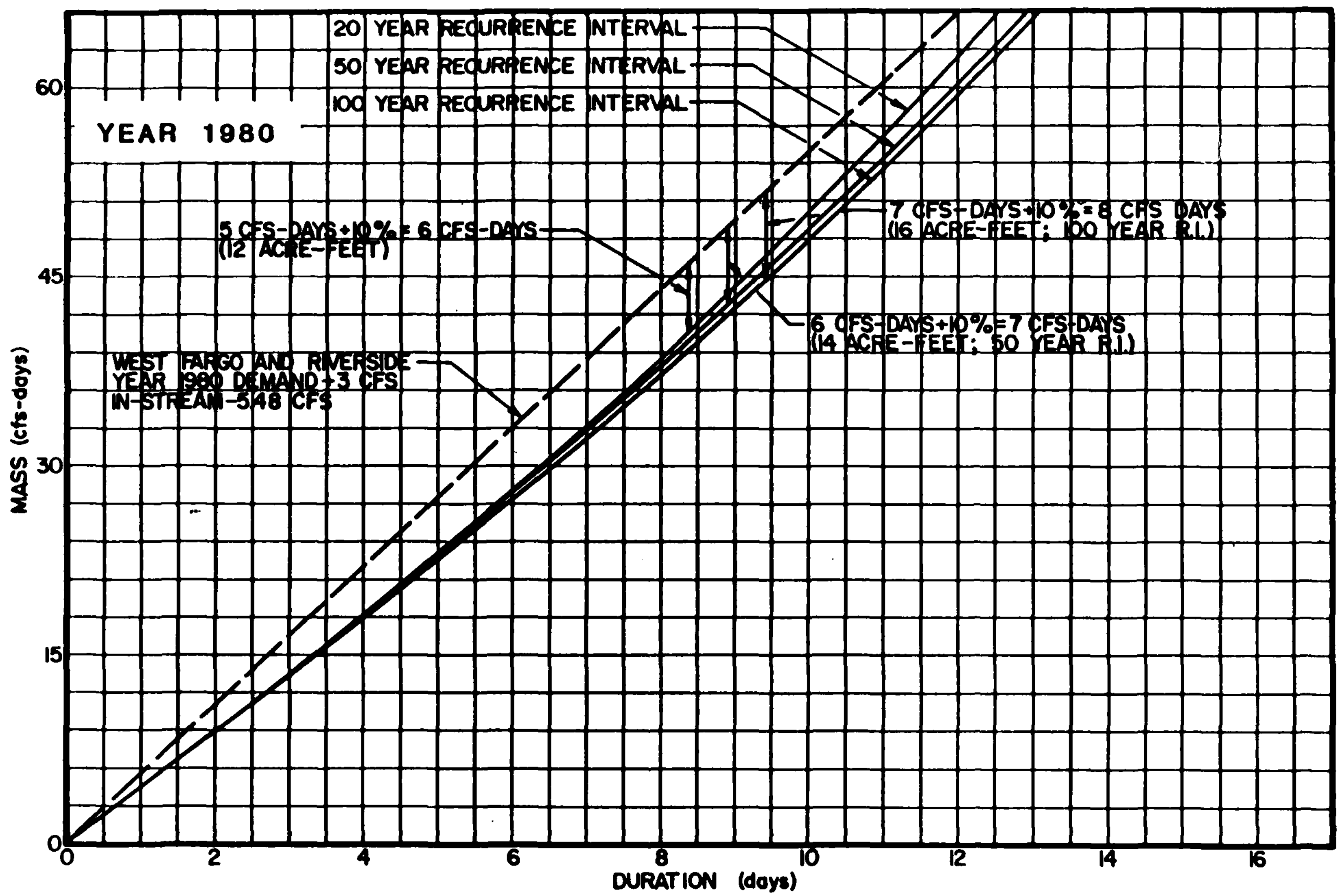


FIGURE 77: Mass Curves for the Sheyenne River at West Fargo (Alternatives 1-3; Minimum In-Stream Flow Considered)

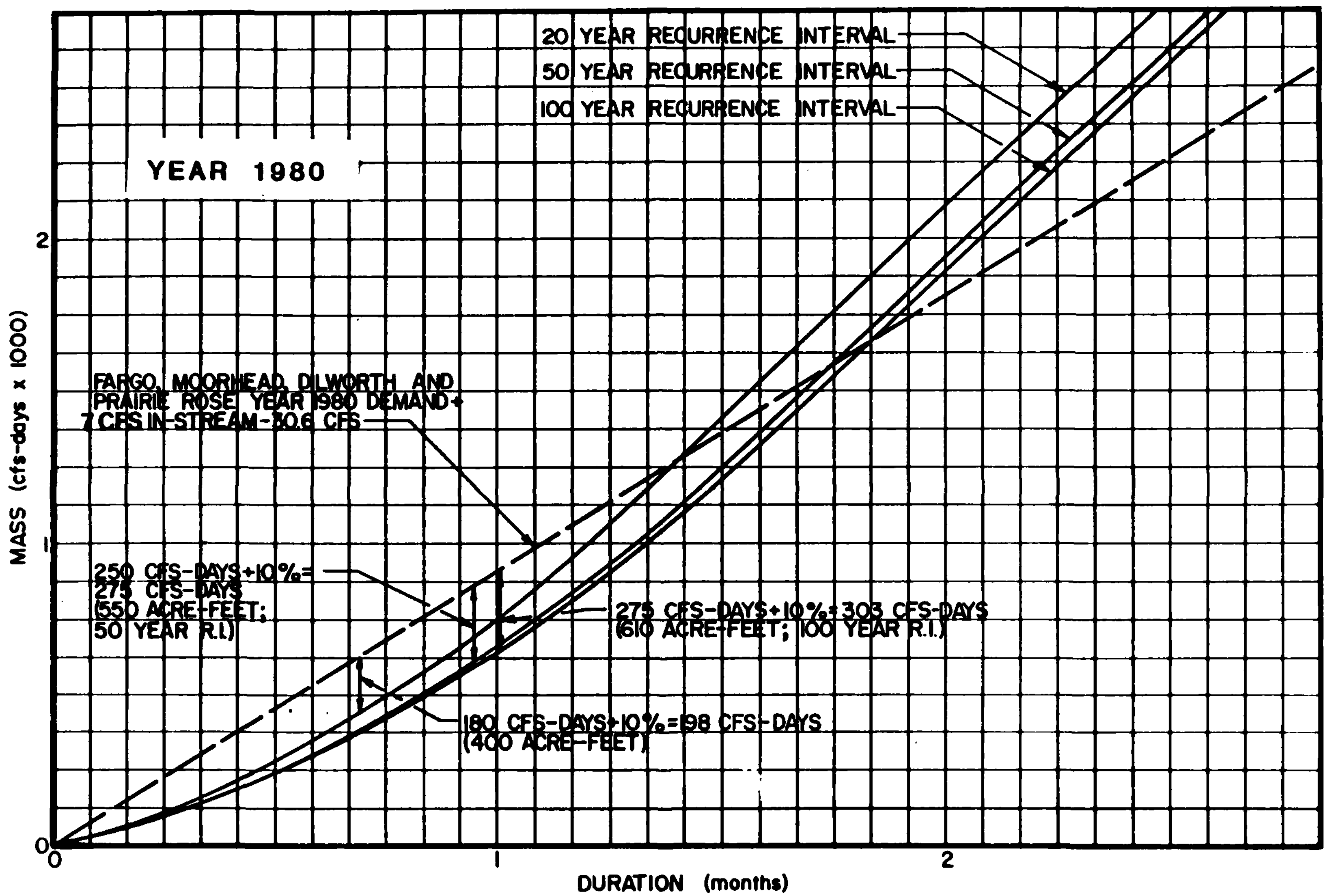


FIGURE 78: Mass Curves for the Red River at Fargo (Alternative 1; Minimum In-Stream Flow Considered)

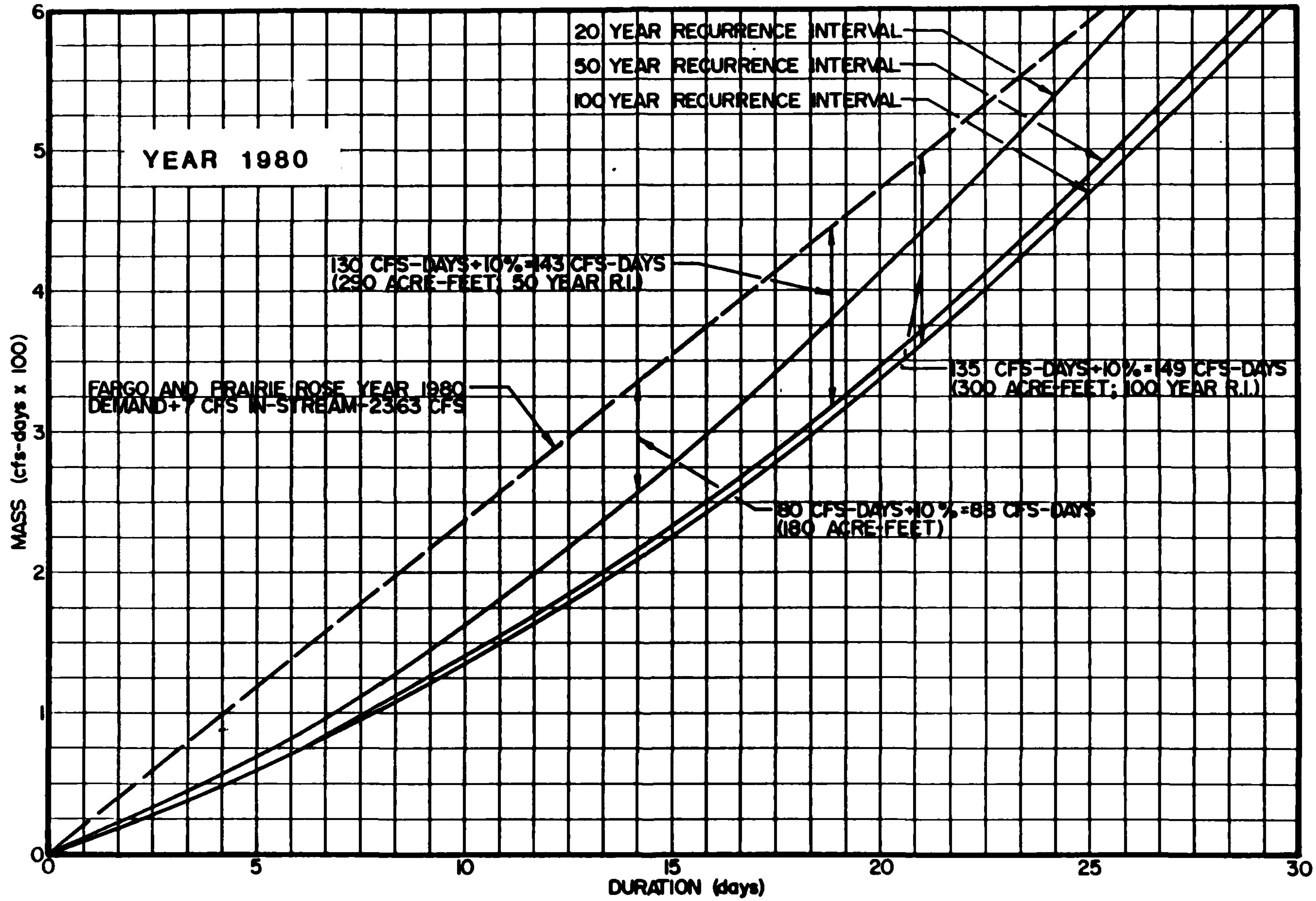


FIGURE 79: Mass Curves for the Red River at Fargo (Alternative 2; Minimum In-Stream Flow Considered)

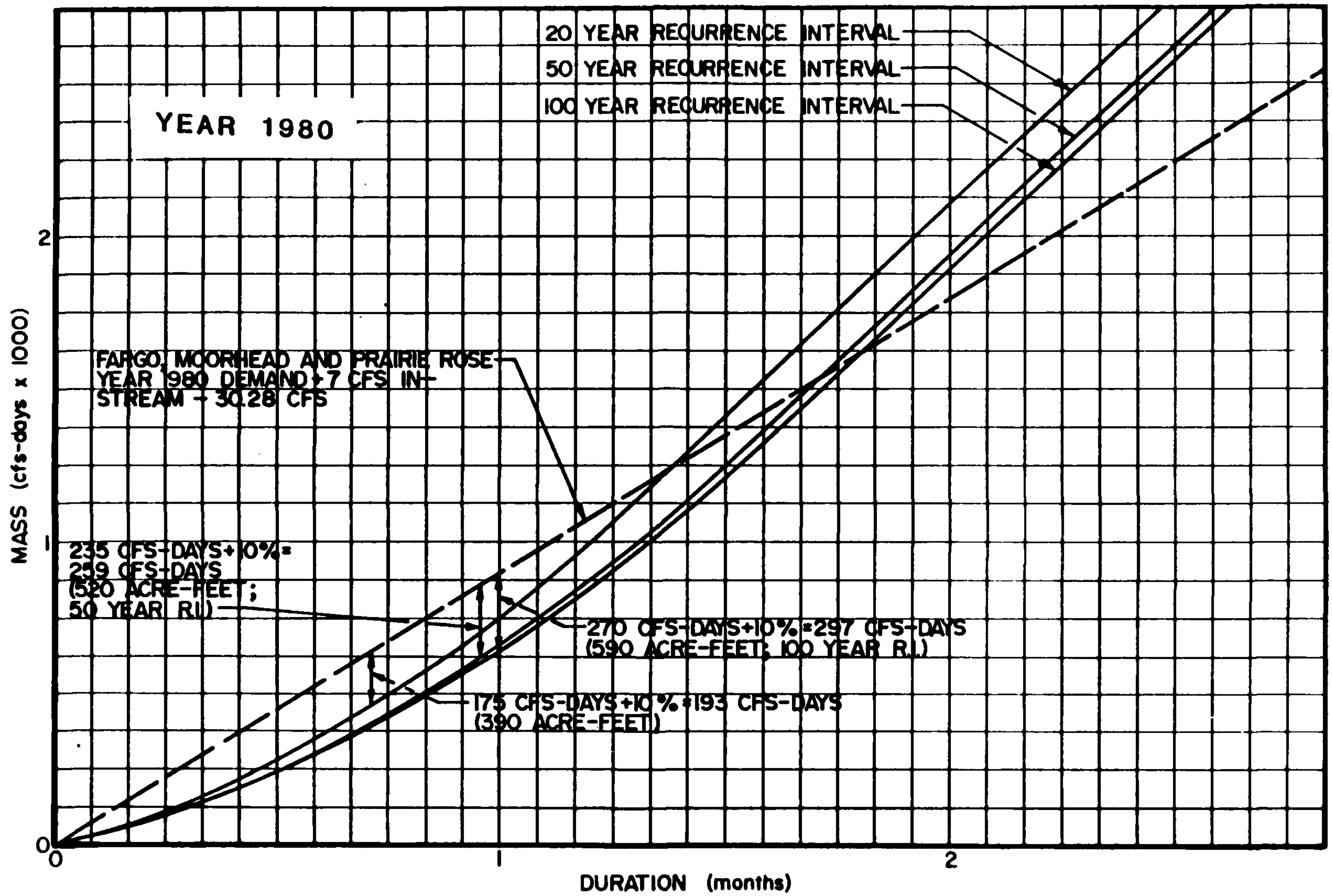


FIGURE 80: Mass Curves for the Red River at Fargo (Alternative 3; Minimum In-Stream Flow Considered)

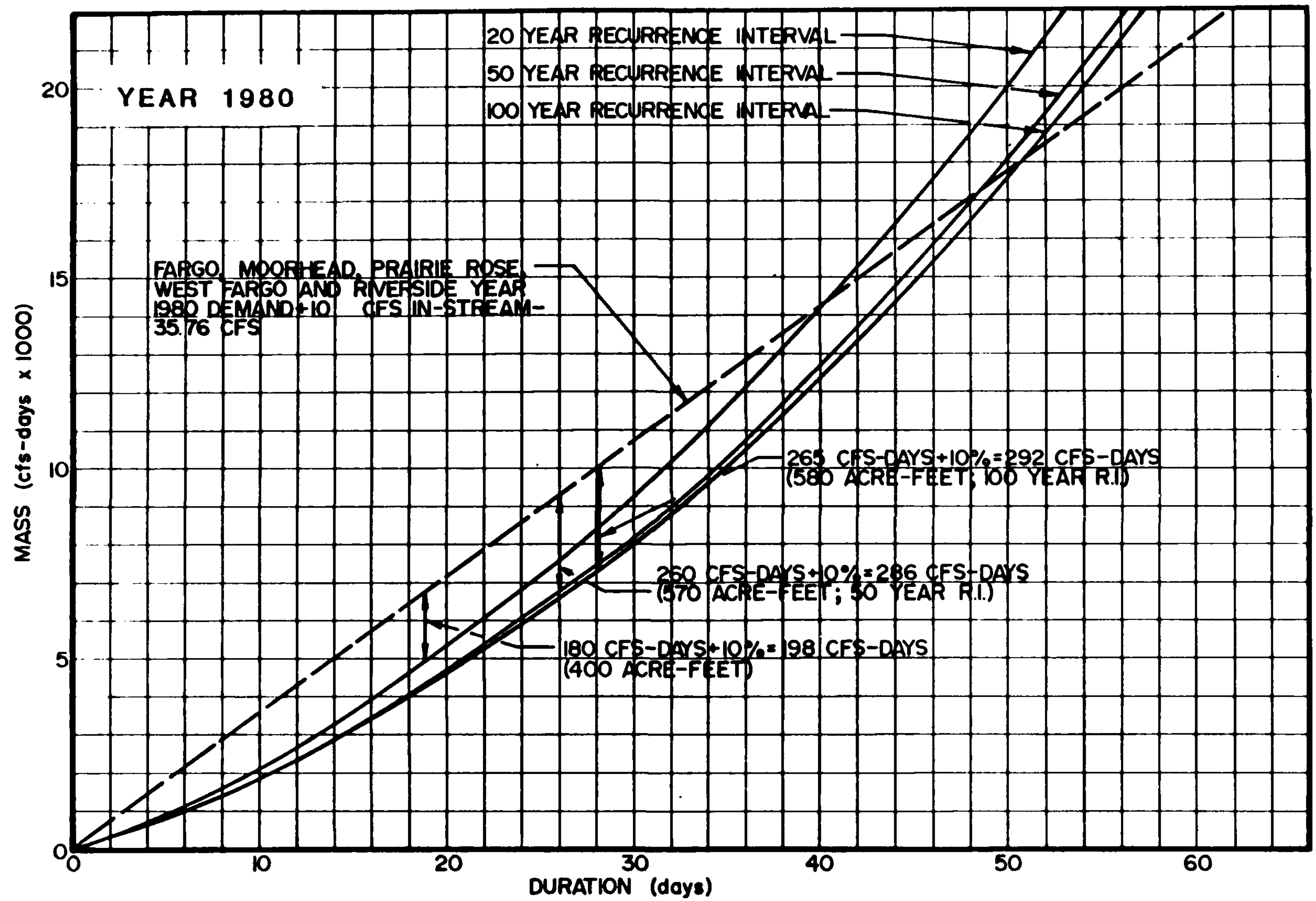


FIGURE 81: Mass Curves for the Sum of the Red River at Fargo and Sheyenne River at West Fargo (Alternative 4; Minimum In-Stream Flows Considered)

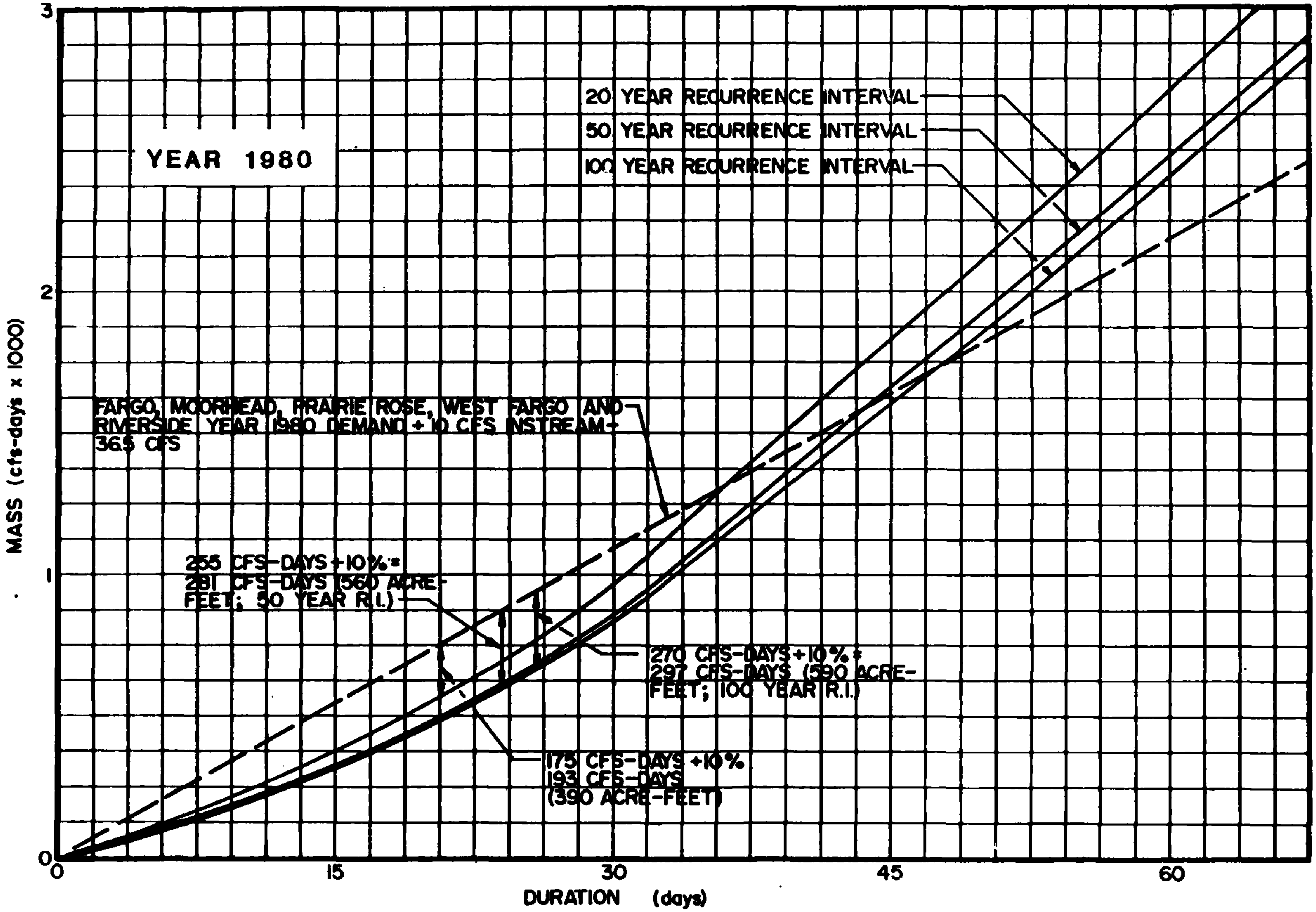


FIGURE 82: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo and Buffalo River (Alternative 5; Minimum In-Stream Flows Considered)

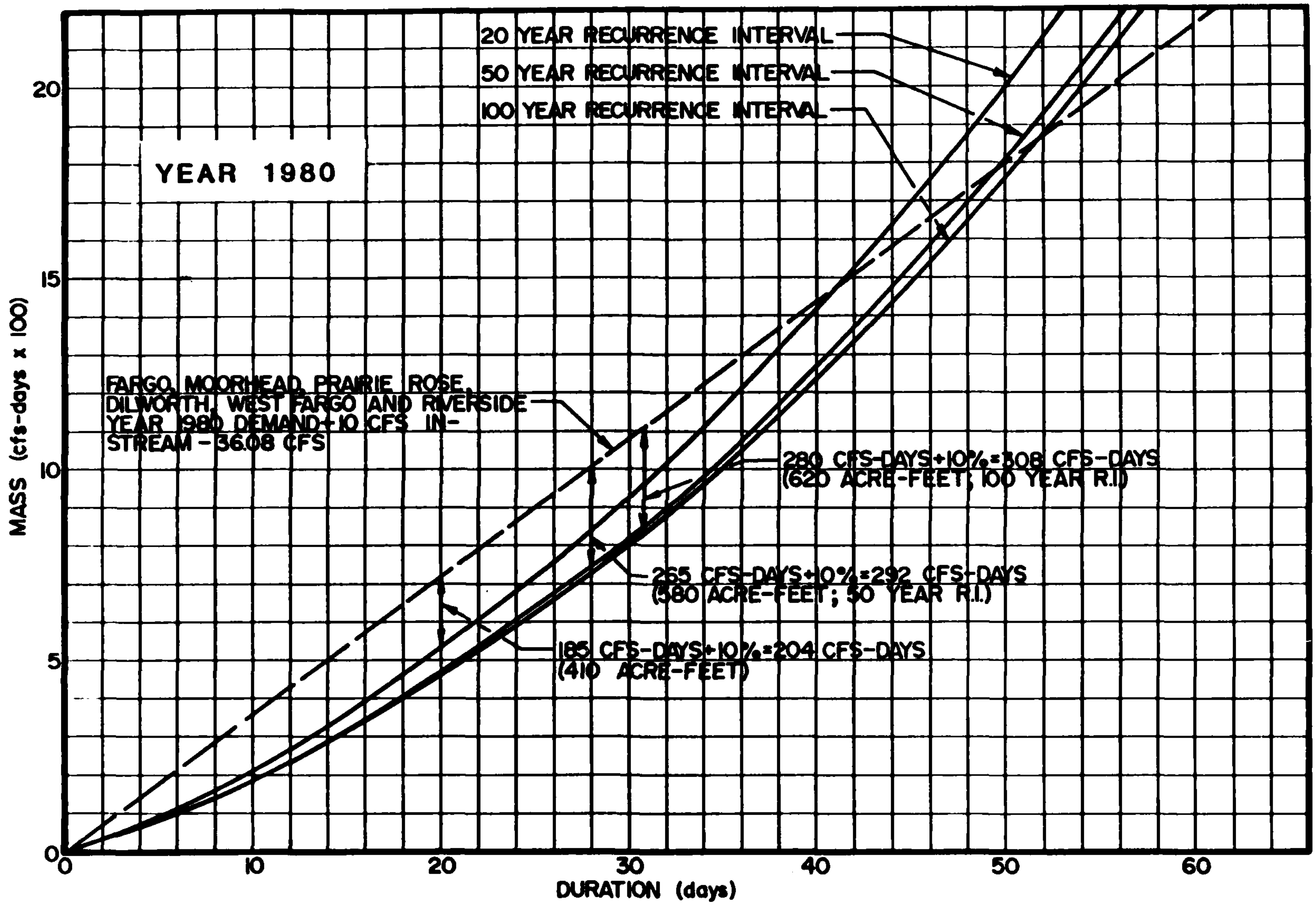


FIGURE 83: Mass Curves for the Sum of the Red River at Fargo and Sheyenne River at West Fargo (Alternative 6; Minimum In-Stream Flows Considered)

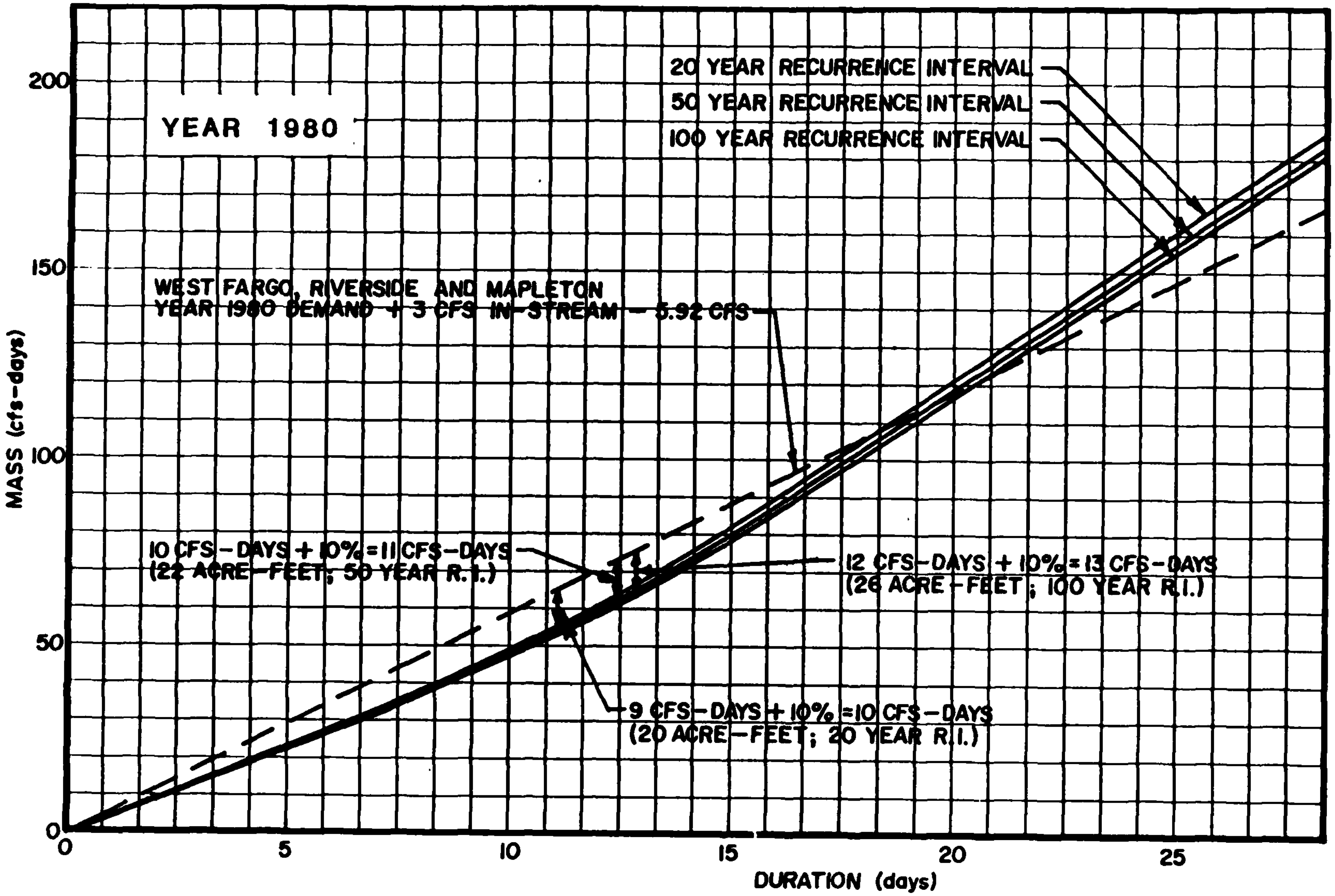


FIGURE 84: Mass Curves for the Sum of the Sheyenne River at West Fargo and Maple River (Alternative 7; Minimum In-Stream Flow Considered)

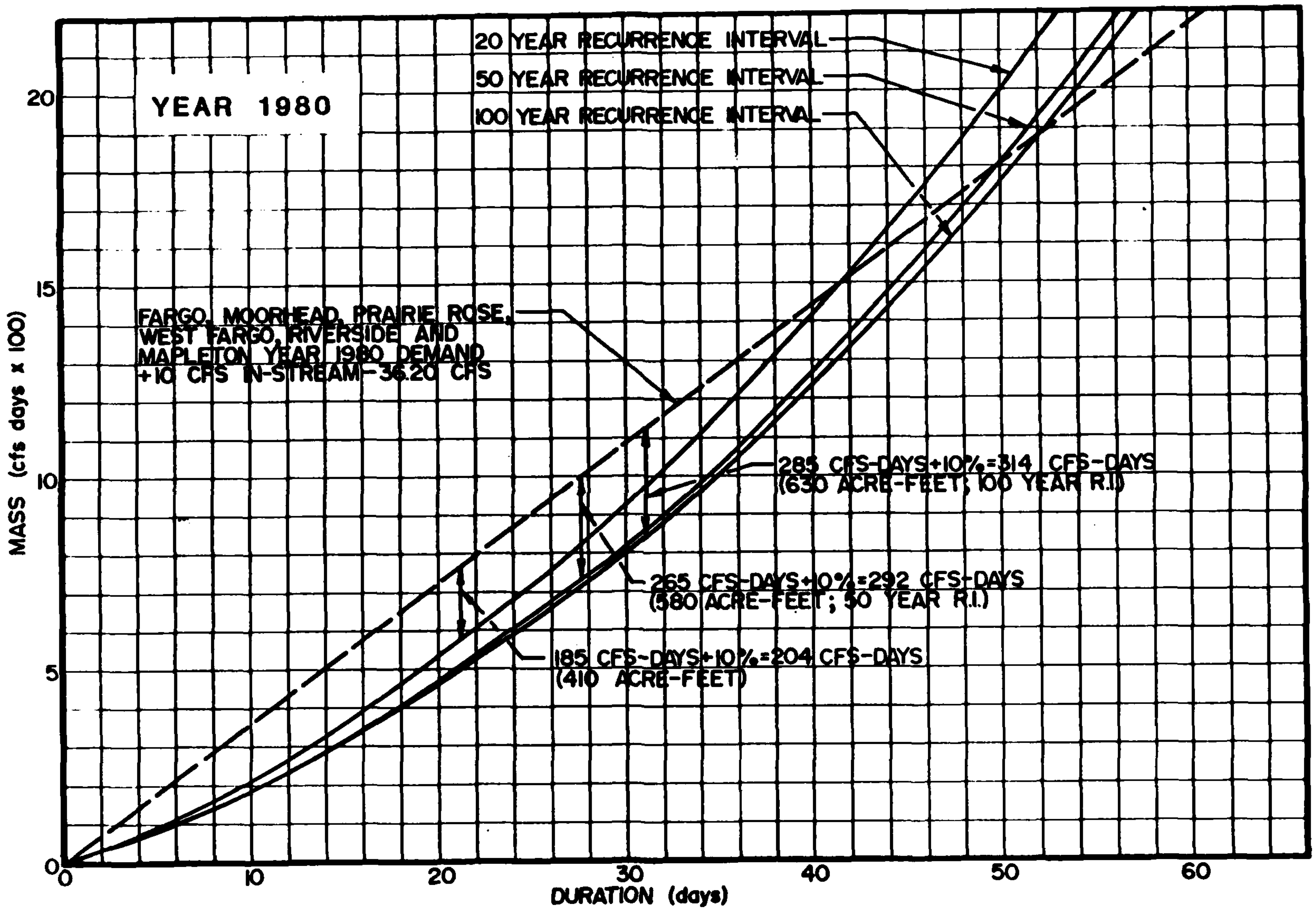


FIGURE 85: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Maple River (Alternative 8; Minimum In-Stream Flows Considered)

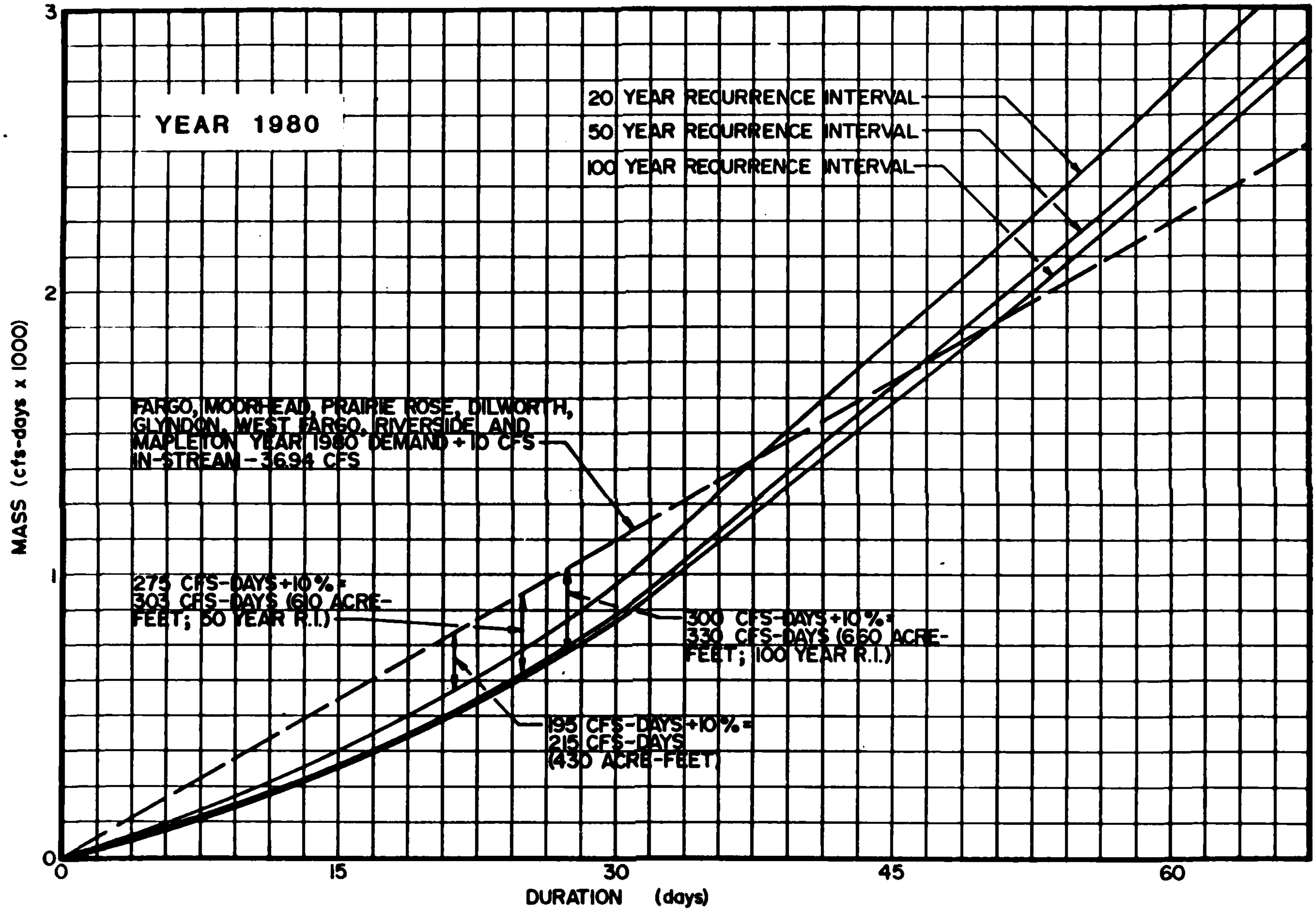


FIGURE 86: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Buffalo and Maple Rivers (Alternative 9; Minimum In-Stream Flows Considered)

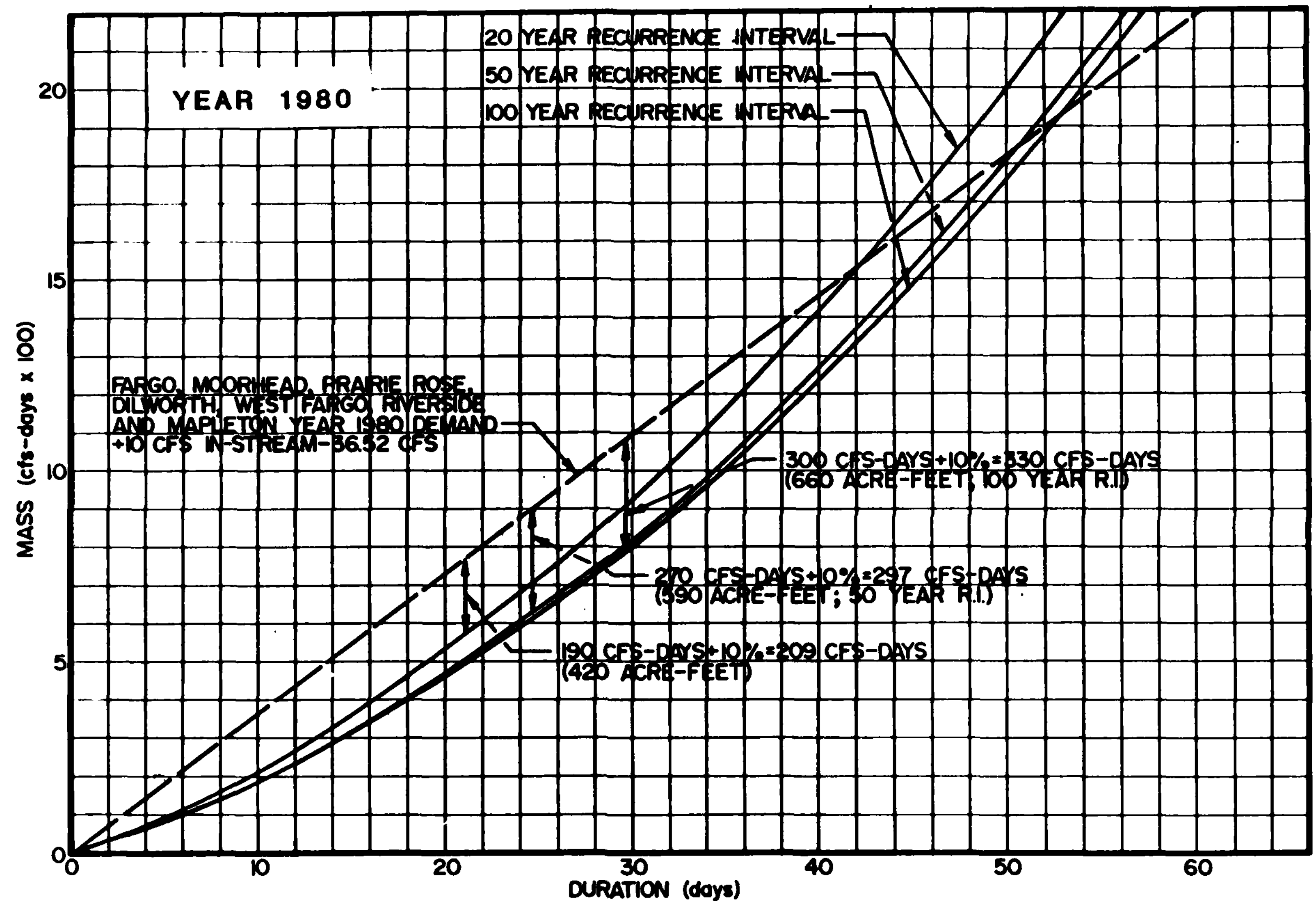


FIGURE 87: Mass Curves for the Sum of the Red River at Fargo, Sheyenne River at West Fargo, and Maple River (Alternative 10; Minimum In-Stream Flows Considered)

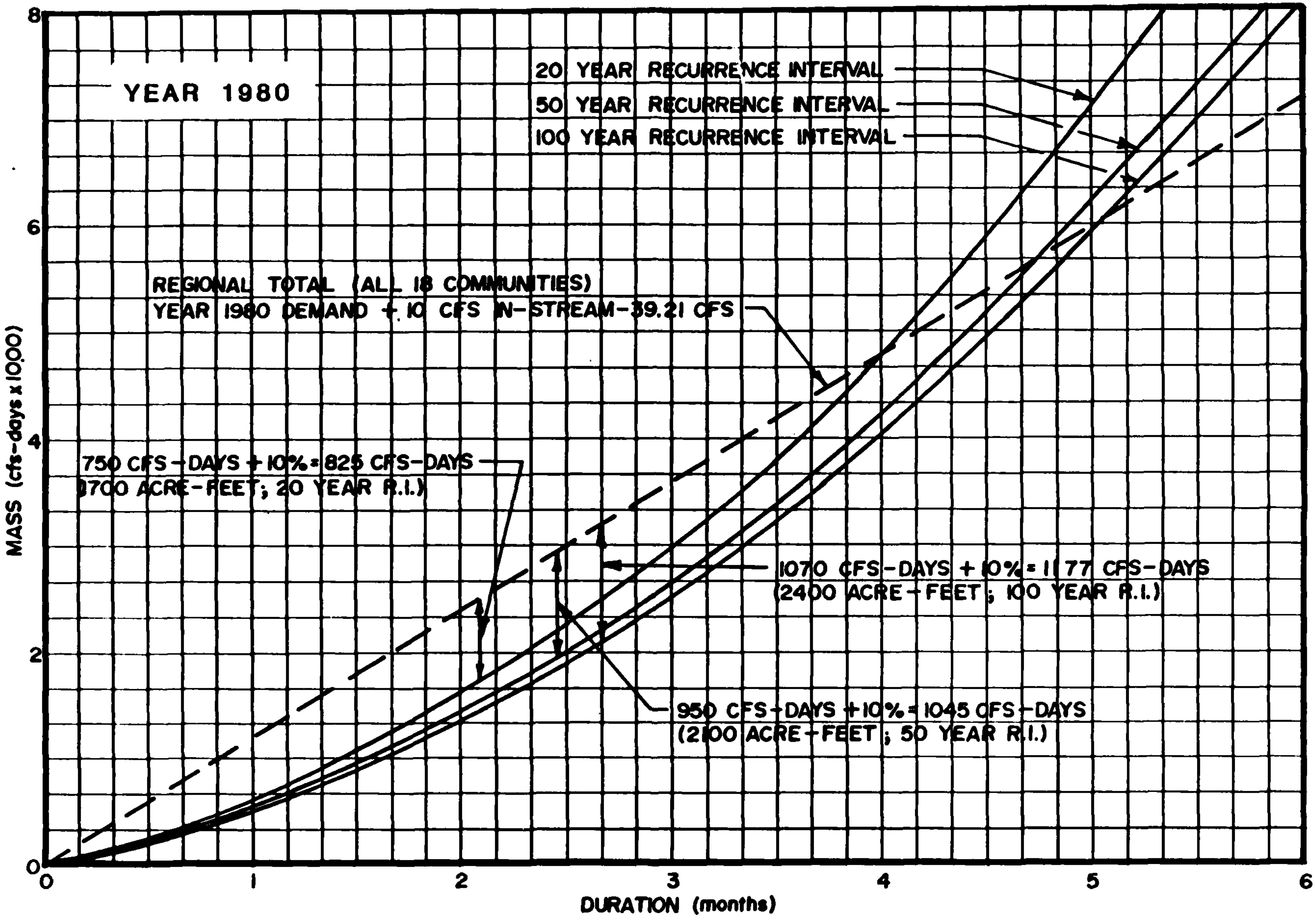


FIGURE 88: Mass Curves for the Sum of the Red River at Rustad, Sheyenne River at Horace, and Buffalo and Maple Rivers (Alternative 11; Minimum In-Stream Flows Considered)

FARGO-MOORHEAD URBAN STUDY

WATER SUPPLY

PHASE 1, PART 2, APPENDIX A

LOW-FLOW FREQUENCY CURVES
FOR THE RED RIVER OF THE NORTH AT FARGO
WITH THE SHEYENNE PIPELINE

APPENDIX A

LOW-FLOW FREQUENCY CURVES FOR THE RED RIVER AT FARGO WITH THE SHEYENNE PIPELINE

Two new sets of low-flow frequency curves were established for the Red River at Fargo with the Sheyenne pipeline in operation. These sets represent year 1980 and year 2030 demand conditions. New flow data were developed by revising pre-existing data for the Red River at Fargo with the Sheyenne diversion. The pre-existing data include the HEC-3 adjustments outlined in Appendix B.

Forty-seven years of historical monthly flows for the Red River at Fargo were examined. Whenever it was determined that 25 cfs was diverted from the Sheyenne to the Red River, the HEC-3 adjusted Red River flows were reduced by that amount. Partial duration analyses were then performed on these revised data. Tabulated versions of the partial duration results are included in this appendix.

Figures A-1 and A-2, Low-Flow Frequency Curves for the Red River at Fargo with the Sheyenne pipeline, are graphical representations of the results of these analyses for year 1980 and year 2030 conditions. Under both conditions, 7-day low flows at longer recurrence intervals fall below 10 cfs. Due to the method of reservoir operation in the HEC-3 model, the year 2030 flows more accurately reflect future streamflows. Under year 2030 conditions, there is a two percent chance in any year that Red River flows could average less than 7 cfs for more than one month. The corresponding 50-year, 7-day low flow is below 1 cfs.

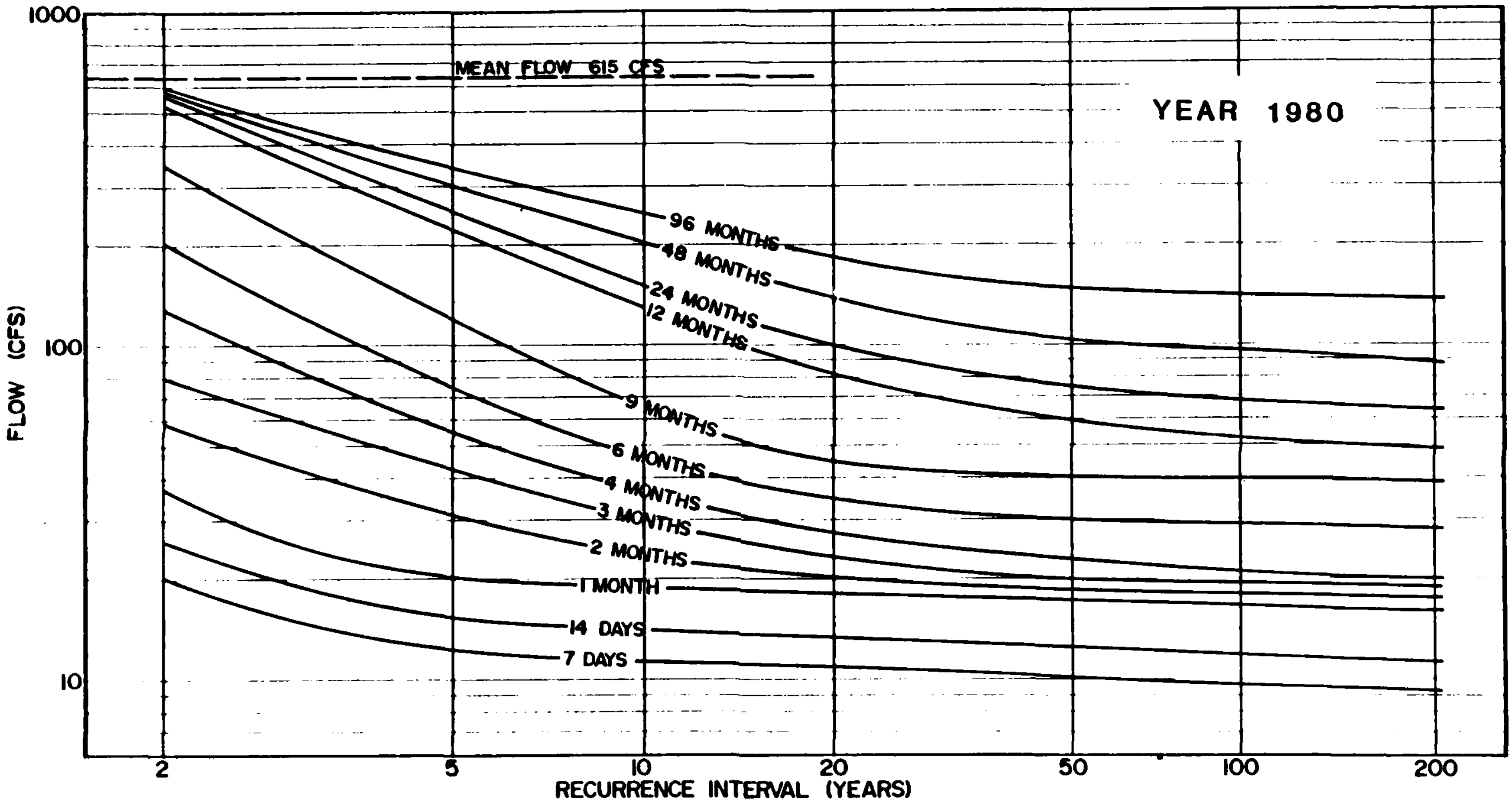


Figure A-1: Low-Flow Frequency Curves, Red River at Fargo With the Sheyenne Pipeline - Year 1980 Case

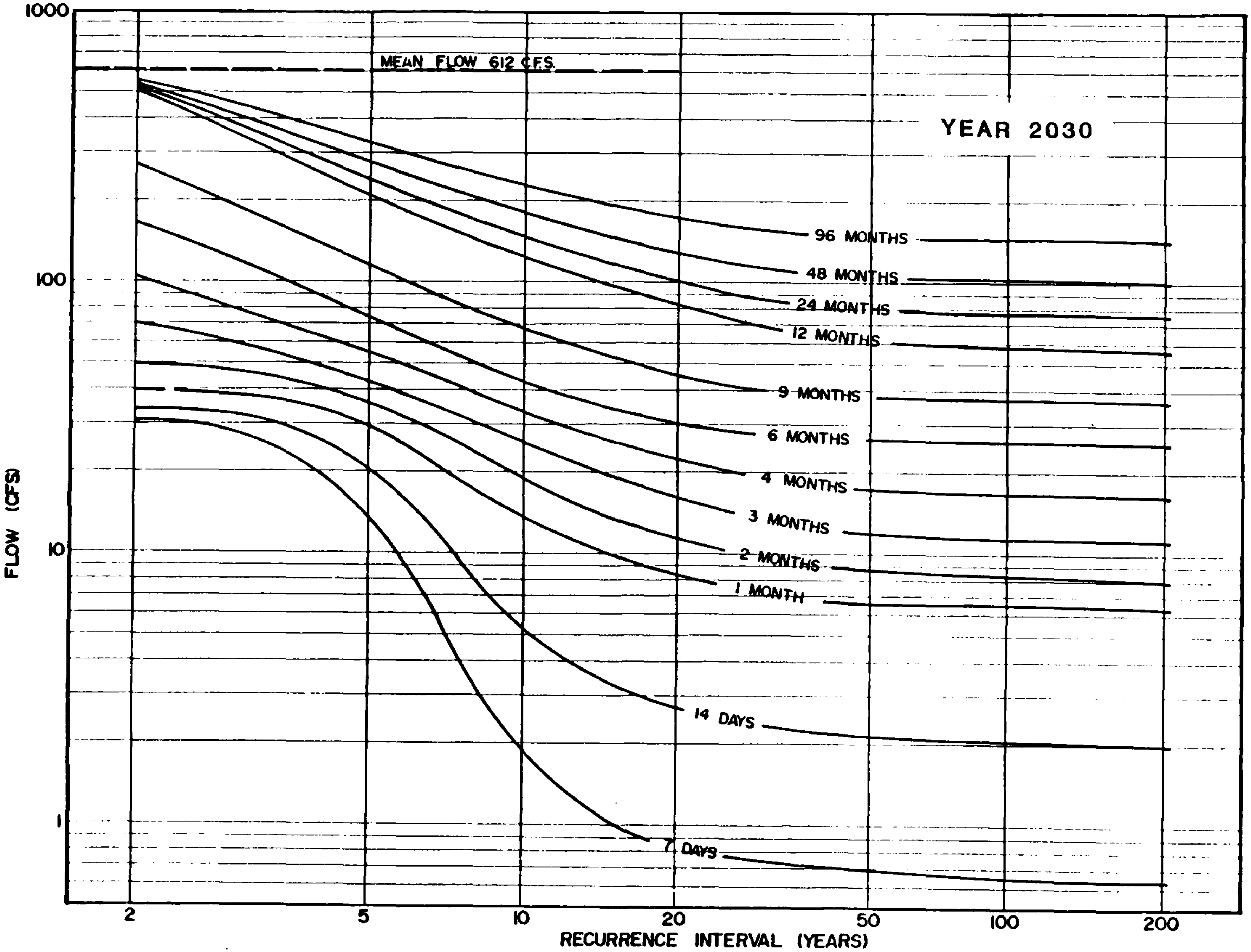


Figure A-2: Low-Flow Frequency Curves, Red River at Fargo With the Sheyenne Pipeline - Year 2030 Case

Red River at Fargo - Year 1980 Case

[illegible] RECORD
[illegible] DURATION [illegible]
4[illegible] 9 2

EFFECTIVE YEARS
46.92

[illegible]	VOLUME AC-FT	RATE CFS	EXCEED PROB	RECUR INT	MONTH YEAR	[illegible]
1	[illegible]	17.4	1.4[illegible]	65.2	10 [illegible]	[illegible]
2	2099.	[illegible]	[illegible]	[illegible]	10 [illegible]	[illegible]
3	2219.	18.4	5.69	17.[illegible]	1[illegible] [illegible]	[illegible]
4	2482.	20.6	7.81	12.8	9 1976	1.[illegible]
5	2823.	23.4	9.92	10.1	10 1940	[illegible]
6	2947.	24.4	12.04	8.3	8 1932	1.13
7	3125.	25.9	14.15	7.1	10 1937	1.02
8	3246.	26.9	16.26	6.1	10 1933	.90
9	3793.	31.4	18.38	5.4	8 1936	.79
10	3913.	32.4	20.49	4.9	8 1934	.70
11	4005.	33.2	22.61	4.4	12 1936	.61
12	4186.	34.7	24.72	4.0	12 1970	.53
13	4695.	38.9	26.83	3.7	10 1931	.46
14	4850.	40.2	28.95	3.5	12 1934	.39
15	4897.	40.6	31.06	3.2	9 1930	.32
16	5298.	43.9	33.18	3.0	10 1935	.26
17	5450.	45.1	35.29	2.8	1 1933	.20
18	5695.	47.2	37.40	2.7	12 1935	.14
19	5873.	48.6	39.52	2.5	1 1938	.09
20	5933.	49.1	41.63	2.4	2 1937	.03
21	5994.	49.6	43.75	2.3	2 1935	-.02
22	6054.	50.1	45.86	2.2	1 1940	[illegible]
23	6178.	51.2	47.97	2.1	12 1933	-.12
24	6658.	55.1	50.09	2.0	2 1936	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	[illegible]
1	3348.	18.5	1.4	69.1	11 [illegible]	[illegible]
2	3448.	19.0	3.57	27.9	10 1934	[illegible]
3	3529.	19.7	5.70	17.5	10 1932	[illegible]
4	5138.	28.4	7.82	12.8	10 1939	1.51
5	5138.	28.4	9.94	10.1	10 1940	1.31
6	6185.	34.2	12.06	8.3	11 1933	1.15
7	7484.	41.3	14.18	7.1	1 1935	1.01
8	8298.	45.8	16.29	6.1	11 1935	.90
9	8459.	46.7	18.41	5.4	10 1931	.79
10	8508.	47.0	20.53	4.9	2 1933	.70
11	8571.	47.3	22.65	4.4	1 1971	.61
12	8689.	48.0	24.76	4.0	2 1937	.53
13	9353.	51.6	26.88	3.7	2 1936	.46
14	9534.	52.6	29.00	3.4	2 1938	.39
15	9658.	53.3	31.12	3.2	1 1940	.32
16	9727.	53.7	33.23	3.0	8 1936	.26
17	10149.	56.0	35.35	2.8	10 1930	.20
18	10440.	57.6	37.47	2.7	2 1934	.14
19	12314.	68.0	39.59	2.5	1 1970	.08
20	12593.	69.5	41.71	2.4	9 1976	.03
21	12616.	69.7	43.82	2.3	1 1932	[illegible]
22	12674.	70.0	45.94	2.2	2 1931	-.0[illegible]
23	12826.	70.8	48.06	2.1	11 1938	-.12
24	14074.	77.7	50.13	2.0	8 1933	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4697.	17.5	1.47	67.[illegible]	11 1936	2.8[illegible]
2	5167.	21.4	3.59	27.8	10 1932	2.1[illegible]
3	5482.	22.7	5.71	17.5	11 1934	1.[illegible]6
4	8742.	36.2	7.84	12.8	11 1939	1.50
5	9424.	39.0	9.96	10.0	12 1933	1.31
6	9889.	40.9	12.08	8.3	11 1940	1.15
7	10993.	45.5	14.20	7.0	12 1935	1.01
8	11568.	47.9	16.32	6.1	2 1933	.89
9	12684.	52.5	18.44	5.4	12 1931	.79
10	15443.	63.9	20.56	4.9	11 1930	.70
11	15613.	64.7	22.69	4.4	2 1938	.61
12	16338.	67.7	24.81	4.0	2 1970	.53
13	16608.	68.8	26.93	3.7	12 1938	.45
14	17002.	70.4	29.05	3.4	2 1971	.38
15	17304.	71.7	31.17	3.2	4 1934	.32
16	17602.	72.9	33.29	3.0	3 1937	.25
17	19353.	80.1	35.42	2.8	3 1940	.20
18	22940.	95.0	37.54	2.7	1 1930	.14
19	23853.	98.8	39.66	2.5	12 1961	.08
20	27226.	112.7	41.78	2.4	1 1975	.03
21	27926.	115.6	43.90	2.3	3 1931	-.02
22	28911.	119.7	46.02	2.2	9 1976	-.07
23	29982.	124.2	48.14	2.1	2 1949	-.12
24	30706.	127.2	50.27	2.0	4 1932	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	9896.	27.3	1.48	67.7	12 1936	[illegible]
2	10862.	30.0	3.61	27.7	12 1934	2.13
3	10982.	30.3	5.73	17.4	12 1932	1.76
4	14796.	40.8	7.86	12.7	1 1940	1.50
5	16185.	44.7	9.99	10.0	1 1934	1.31
6	17651.	48.7	12.12	8.2	2 1936	1.15
7	19747.	54.5	14.25	7.0	1 1941	1.01
8	21075.	58.2	16.38	6.1	1 1932	.89
9	23067.	63.7	18.51	5.4	1 1931	.79
10	29105.	80.3	20.64	4.8	1 1939	.69
11	30813.	85.1	22.77	4.4	2 1970	.61
12	32805.	90.6	24.90	4.0	2 1938	.53
13	37557.	103.7	27.02	3.7	1 1962	.45
14	44457.	122.7	29.15	3.4	2 1971	.38
15	45966.	126.9	31.28	3.2	2 1957	.31
16	49209.	135.8	33.41	3.0	1 1942	.25
17	51460.	142.1	35.54	2.8	2 1949	.19
18	54056.	149.2	37.67	2.7	2 1950	.13
19	54623.	150.8	39.80	2.5	6 1933	.08
20	62207.	171.7	41.93	2.4	2 1961	.03
21	62267.	171.9	44.06	2.3	2 1968	-.03
22	63286.	174.7	46.19	2.2	3 [illegible]	-.08
23	66929.	184.8	48.31	2.1	7 1931	-.13
24	69693.	192.4	50.44	2.0	2 1951	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	20858.	38.4	1.48	67.3	2 1933	2.83
2	21341.	39.3	3.63	27.6	2 1935	2.12
3	21763.	40.1	5.77	17.3	2 1937	1.75
4	30190.	55.6	7.91	12.6	4 1934	1.50
5	39051.	71.9	10.05	10.0	3 1940	1.30
6	47141.	86.8	12.19	8.2	3 1932	1.14
7	48690.	89.6	14.33	7.0	2 1936	1.01
8	50294.	92.6	16.47	6.1	4 1931	.89
9	55451.	102.1	18.61	5.4	2 1941	.78
10	65749.	121.0	20.75	4.8	4 1938	.69
11	72437.	133.3	22.89	4.4	3 1962	.60
12	74409.	136.9	25.03	4.0	2 1939	.52
13	86263.	158.8	27.17	3.7	3 1942	.45
14	98579.	181.4	29.31	3.4	3 1949	.38
15	109157.	200.9	31.45	3.2	4 1961	.31
16	111136.	204.5	33.59	3.0	3 1970	.25
17	111740.	205.6	35.73	2.8	3 1957	.19
18	128162.	235.9	37.87	2.6	3 1965	.13
19	128718.	236.9	40.01	2.5	4 1959	.07
20	130650.	240.4	42.15	2.4	4 1968	.02
21	131466.	242.0	44.29	2.3	5 1971	-.03
22	137097.	252.3	46.43	2.2	3 1964	-.08
23	154923.	285.1	48.57	2.1	6 1930	-.13
24	155511.	286.2	50.71	2.0	3 1960	-.18

(continued)

1

YRS (RECORD) MONTHS 47 0 — DURATION IN MONTHS 12

EFFECTIVE YEARS

46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	42603.	58.8	1.49	67.0	2 1935	2.52
2	47554.	65.6	3.64	27.4	3 1933	2.12
3	69349.	95.7	5.80	17.3	3 1937	1.75
4	87038.	120.1	7.95	12.6	12 1931	1.49
5	96999.	133.9	10.10	9.9	3 1936	1.30
6	97422.	134.5	12.25	8.2	7 1940	1.14
7	115051.	158.8	14.40	6.9	11 1938	1.00
8	131533.	181.6	16.56	6.0	3 1962	.88
9	151999.	209.8	18.71	5.3	7 1941	.78
10	164134.	226.6	20.86	4.8	12 1930	.68
11	183514.	253.3	23.01	4.3	6 1949	.60
12	216236.	298.5	25.16	4.0	6 1971	.52
13	221247.	305.4	27.32	3.7	5 1959	.44
14	238876.	329.7	29.47	3.4	9 1976	.37
15	239057.	330.0	31.62	3.2	8 1968	.30
16	253969.	350.6	33.77	3.0	7 1955	.24
17	260852.	360.1	35.92	2.8	4 1957	.18
18	286208.	395.1	38.07	2.6	9 1973	.12
19	298585.	412.1	40.23	2.5	6 1970	.07
20	302811.	418.0	42.38	2.4	10 1964	.01
21	323157.	446.1	44.53	2.2	2 1961	-.04
22	348634.	481.2	46.68	2.1	7 1942	-.09
23	369221.	509.6	48.83	2.0	6 1946	-.14
24	392465.	541.7	50.99	2.0	3 1975	-.19

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	24

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL
1	112797.	77.8	1.53	65.5	4 1934	[illegible]
2	166[illegible]48.	114.8	3.72	26.8	3 1937	[illegible]
3	204987.	141.5	5.92	16.9	4 1932	1.[illegible]
4	233423.	161.1	8.12	12.3	5 1941	1.4[illegible]
5	295124.	203.7	10.32	9.7	3 1939	1.28
6	459278.	317.0	12.52	8.0	3 1962	1.12
7	492423.	339.8	14.72	6.8	3 1960	.98
8	514821.	355.3	16.92	5.9	6 1971	.86
9	566802.	391.2	19.12	5.2	1 1950	.76
10	584793.	403.6	21.32	4.7	2 1957	.66
11	688695.	475.3	23.52	4.3	3 1965	.58
12	696483.	480.7	25.72	3.9	3 1975	.50
13	858223.	592.3	27.92	3.6	3 1969	.42
14	913766.	630.6	30.12	3.3	3 1947	.35
15	1058963.	730.8	32.31	3.1	2 1955	.28
16	1194742.	824.6	34.51	2.9	5 1943	.22
17	1383709.	955.0	36.71	2.7	1 1952	.16
18	1891507.	1305.4	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	254332.	87.6	1.60	62.7	2 [illegible]	[illegible]
2	440462.	152.0	3.90	25.7	2 1939	2.06
3	935340.	322.6	6.20	16.1	3 1943	1.59
4	931701.	328.4	8.50	11.8	3 1962	1.44
5	1411260.	487.0	10.80	9.3	3 1958	1.24
6	1659936.	572.8	13.10	7.6	3 1950	1.08
7	1667483.	575.4	15.40	6.5	8 1973	.94
8	2504736.	864.3	17.70	5.7	10 1966	.83
9	3123680.	1077.9	20.00	5.0	3 1954	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	676924.	116.8	1.76	56.9	6 1938	2.69
2	2362961.	407.7	4.29	23.3	3 1962	1.99
3	3601815.	621.5	6.82	14.7	6 1946	1.62
4	4208382.	726.1	9.36	10.7	3 1975	1.36

INDEPENDENT EVENTS EXHAUSTED

Red River at Fargo - Year 2030 Case

YEAR 2030 ADJUSTED FLOW RECORD

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL [illegible]
1	1028.	8.5	1.47	68.2	2 1933	2.24
2	1148.	9.5	3.58	27.9	2 193[illegible]	2.13
3	1329.	11.0	5.69	17.6	2 1935	1.76
4	3026.	25.1	7.81	12.8	12 1936	1.51
5	3932.	32.6	9.92	10.1	12 1932	1.31
6	3932.	32.6	12.04	8.3	12 1934	1.15
7	4536.	37.6	14.15	7.1	12 1970	1.02
8	4536.	37.6	16.26	6.1	12 1939	.90
9	4536.	37.6	18.38	5.4	12 1933	.79
10	4717.	39.1	20.49	4.9	12 1940	.70
11	4831.	40.0	22.61	4.4	2 1940	.61
12	4891.	40.5	24.72	4.0	2 1934	.53
13	4946.	41.0	26.83	3.7	11 1935	.46
14	5308.	44.0	28.95	3.5	11 1931	.39
15	5371.	44.5	31.06	3.2	10 1940	.32
16	5371.	44.5	33.18	3.0	10 1936	.26
17	5371.	44.5	35.29	2.8	10 1939	.20
18	5371.	44.5	37.40	2.7	10 1933	.14
19	5371.	44.5	39.52	2.5	10 1932	.09
20	5371.	44.5	41.63	2.4	10 1934	.03
21	5737.	47.5	43.75	2.3	1 1938	-.02
22	5794.	48.0	45.86	2.2	10 1930	-.07
23	5857.	48.5	47.97	2.1	1 1936	-.12
24	6348.	52.6	50.09	2.0	9 1970	-.17

(continued)

EARS (RECORD) MONTHS　　DURATION IN MONTHS
47　　0　　3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	CUMUL R.
1	1843.	10.2	1.47	68.1	2 19[illegible]	[illegible]
2	2629.	14.5	3.59	27.9	2 1933	2.13
3	2930.	16.2	5.70	17.5	2 1935	1.76
4	6921.	38.2	7.82	12.8	1 1940	1.31
5	6921.	38.2	9.94	10.1	1 1934	1.31
6	7210.	39.8	12.06	8.3	12 1940	1.15
7	7573.	41.8	14.18	7.1	12 1935	1.01
8	7703.	42.5	16.29	6.1	11 1936	.90
9	7703.	42.5	18.41	5.4	11 1934	.79
10	7703.	42.5	20.53	4.9	11 1932	.70
11	8186.	45.2	22.65	4.4	11 1931	.61
12	8430.	46.5	24.76	4.0	1 1971	.53
13	8842.	48.8	26.88	3.7	10 1939	.46
14	8842.	48.8	29.00	3.4	10 1933	.39
15	9264.	51.1	31.12	3.2	10 1930	.32
16	9329.	51.5	33.23	3.0	2 1938	.26
17	11304.	62.4	35.35	2.8	8 1932	.20
18	11666.	64.4	37.47	2.7	8 1934	.14
19	12113.	66.9	39.59	2.5	1 1970	.08
20	12223.	67.5	41.71	2.4	10 1938	.03
21	12469.	68.8	43.82	2.3	2 1931	-.02
22	12571.	69.4	45.94	2.2	9 1940	-.07
23	13115.	72.4	48.06	2.1	8 1936	-.12
24	13616.	75.2	50.18	2.0	2 1932	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4175.	17.3	1.47	67.9	2 1937	2.83
2	4960.	20.5	3.59	27.8	2 1933	2.13
3	5262.	21.8	5.71	17.5	2 1935	1.76
4	9367.	38.8	7.84	12.8	2 1940	1.50
5	9415.	39.0	9.96	10.0	1 1934	1.31
6	10088.	41.8	12.08	8.3	12 1940	1.15
7	10451.	43.3	14.20	7.0	12 1935	1.01
8	11656.	48.3	16.32	6.1	11 1931	.89
9	12710.	52.6	18.44	5.4	10 1936	.79
10	12710.	52.6	20.56	4.9	10 1934	.70
11	12710.	52.6	22.69	4.4	10 1932	.61
12	14494.	60.0	24.81	4.0	11 1930	.53
13	15344.	63.5	26.93	3.7	2 1938	.45
14	16005.	66.3	29.05	3.4	12 1938	.38
15	16068.	66.5	31.17	3.2	2 1970	.32
16	16658.	69.0	33.29	3.0	9 1933	.25
17	16793.	69.5	35.42	2.8	2 1971	.20
18	19109.	79.1	37.54	2.7	10 1939	.14
19	22636.	93.7	39.66	2.5	1 1930	.08
20	23250.	96.3	41.78	2.4	12 1961	.03
21	23453.	97.1	43.90	2.3	5 1934	-.02
22	26923.	111.5	46.02	2.2	1 1975	-.07
23	27653.	114.5	48.14	2.1	3 1931	-.12
24	28740.	119.0	50.27	2.0	3 1932	-.17

(continued)

1
YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	9546.	26.4	1.48	67.7	2 1937	2.83
2	10331.	28.5	3.61	27.7	2 1933	2.13
3	10633.	29.4	5.73	17.4	2 1935	1.76
4	14738.	40.7	7.86	12.7	2 1940	1.50
5	14799.	40.9	9.99	10.0	2 1934	1.31
6	16972.	46.9	12.12	8.2	2 1936	1.15
7	18540.	51.2	14.25	7.0	1 1941	1.01
8	19868.	54.8	16.38	6.1	1 1932	.89
9	21981.	60.7	18.51	5.4	1 1931	.79
10	27898.	77.0	20.64	4.8	1 1939	.69
11	30073.	83.0	22.77	4.4	2 1970	.61
12	32065.	88.5	24.90	4.0	2 1938	.53
13	32613.	90.0	27.02	3.7	8 1934	.45
14	36350.	100.3	29.15	3.4	1 1962	.38
15	40462.	111.7	31.28	3.2	8 1932	.31
16	43778.	120.9	33.41	3.0	2 1971	.25
17	45227.	124.9	35.54	2.8	2 1957	.19
18	48002.	132.5	37.67	2.7	1 1942	.13
19	50721.	140.0	39.80	2.5	2 1949	.08
20	52718.	145.5	41.93	2.4	8 1933	.03
21	53317.	147.2	44.06	2.3	2 1950	-.03
22	61467.	169.7	46.19	2.2	2 1961	-.08
23	61527.	169.9	48.31	2.1	2 1968	-.13
24	62846.	173.5	50.44	2.0	3 1975	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL F
1	21635.	39.8	1.46	67.3	2 1933	[illegible]
2	22299.	41.0	3.63	27.6	2 1935	[illegible]
3	22662.	41.7	5.77	17.3	2 1937	[illegible]
4	28578.	52.6	7.91	12.6	2 1934	1.50
5	37020.	68.1	10.05	10.0	3 1940	1.30
6	45109.	83.0	12.19	8.2	3 1932	1.14
7	46630.	85.8	14.33	7.0	2 1936	1.01
8	49007.	90.2	16.47	6.1	4 1931	.89
9	53331.	98.2	18.61	5.4	2 1941	.78
10	65005.	119.6	20.75	4.8	4 1938	.69
11	70406.	129.6	22.89	4.4	3 1962	.60
12	72288.	133.0	25.03	4.0	2 1939	.52
13	84231.	155.0	27.17	3.7	3 1942	.45
14	96547.	177.7	29.31	3.4	3 1949	.38
15	107750.	198.3	31.45	3.2	4 1961	.31
16	109105.	200.8	33.59	3.0	3 1970	.25
17	109709.	201.9	35.73	2.8	3 1957	.19
18	126130.	232.1	37.87	2.6	3 1965	.13
19	127310.	234.3	40.01	2.5	4 1959	.07
20	129242.	237.9	42.15	2.4	4 1968	.02
21	130471.	240.1	44.29	2.3	5 1971	-.03
22	135609.	249.6	46.43	2.2	3 1964	-.08
23	153479.	282.5	48.57	2.1	3 1960	-.13
24	[illegible]	282.9	50.71	2.0	2 1950	-.13

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL
1	43246.	59.7	1.49	67.0	2 1935	2.82
2	44997.	62.1	3.64	27.4	3 1933	2.12
3	66973.	92.4	5.80	17.3	3 1937	1.75
4	84602.	116.8	7.95	12.6	12 1931	1.47
5	94624.	130.6	10.10	9.9	3 1936	1.30
6	94986.	131.1	12.25	8.2	7 1940	1.14
7	112615.	155.4	14.40	6.9	11 1938	1.00
8	129097.	178.2	16.56	6.0	3 1962	.88
9	149563.	206.4	18.71	5.3	7 1941	.78
10	161819.	223.4	20.86	4.8	12 1930	.68
11	181078.	249.9	23.01	4.3	6 1949	.60
12	213860.	295.2	25.16	4.0	6 1971	.52
13	218811.	302.0	27.32	3.7	5 1959	.44
14	236621.	326.6	29.47	3.4	8 1968	.37
15	241209.	332.9	31.62	3.2	9 1976	.30
16	251533.	347.2	33.77	3.0	7 1955	.24
17	258416.	356.7	35.92	2.8	4 1957	.18
18	283772.	391.7	38.07	2.6	9 1973	.12
19	296149.	408.8	40.23	2.5	6 1970	.07
20	300375.	414.6	42.38	2.4	10 1964	.01
21	320721.	442.7	44.53	2.2	2 1961	-.04
22	346198.	477.9	46.68	2.1	7 1942	-.09
23	366785.	506.3	48.83	2.0	6 1946	-.14
24	390029.	538.4	50.99	2.0	3 1975	-.19

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL
1	108952.	75.2	1.53	65.3	4 1934	2.21
2	161397.	111.5	3.72	26.8	3 1927	2.16
3	200236.	138.2	5.92	16.9	4 1932	1.73
4	228550.	157.7	8.12	12.3	5 1941	1.47
5	290252.	200.3	10.32	9.7	3 1939	1.25
6	454406.	313.6	12.52	8.0	3 1962	1.12
7	487551.	336.5	14.72	6.8	3 1960	.98
8	510009.	352.0	16.92	5.9	6 1971	.86
9	561930.	387.8	19.12	5.2	1 1950	.76
10	579921.	400.2	21.32	4.7	2 1957	.66
11	684367.	472.3	23.52	4.3	3 1965	.58
12	691611.	477.3	25.72	3.9	3 1975	.50
13	851721.	587.8	27.92	3.6	3 1969	.42
14	908894.	627.3	30.12	3.3	3 1947	.35
15	1054091.	727.5	32.31	3.1	2 1955	.28
16	1189870.	821.2	34.51	2.9	5 1943	.22
17	1378837.	951.6	36.71	2.7	1 1952	.16
18	1886635.	1302.1	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   [illegible]   43

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	247546.	85.4	1.60	62.7	2 [illegible]	[illegible]
2	427880.	147.7	3.90	25.[illegible]	2 1959	[illegible]
3	925595.	319.4	6.20	16.1	3 194[illegible]	1.[illegible]
4	941956.	325.0	8.50	11.8	3 1962	1.44
5	1401516.	483.6	10.80	9.3	3 1958	1.24
6	1650192.	569.4	13.10	7.6	3 1950	1.08
7	1657799.	572.1	15.40	6.5	8 1973	.94
8	2495535.	861.2	17.70	5.7	10 1966	.83
9	3113935.	1074.5	20.00	5.0	3 1954	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	657677.	113.5	1.76	56.9	6 1938	2.69
2	2343472.	404.3	4.29	23.3	3 1962	1.99
3	3582326.	618.1	6.82	14.7	6 1946	1.62
4	4187324.	722.3	9.36	10.7	3 1975	1.36

INDEPENDENT EVENTS EXHAUSTED

FARGO-MOORHEAD URBAN STUDY

WATER SUPPLY

PHASE 1, PART 2, APPENDIX B

HEC-3 DATA ADJUSTMENTS
AND INITIAL HEC-4 STREAMFLOW CORRELATIONS

APPENDIX B
HEC-3 DATA ADJUSTMENTS

The following pages outline adjustments to HEC-3 Run 16 output necessary to obtain flow records at selected locations on the Red, Sheyenne and Buffalo Rivers. The adjustments are year 2030 projected demands or return flows for municipal, industrial, irrigation, or livestock water use. Abbreviated terminology is used to identify the demand and return flow adjustments. Following are some examples with definitions:

- new Q_w West Fargo, Riverside	Subtract (-) the West Fargo and Riverside municipal demands (Q_w), developed in the 1982 (new) study, from the reference flow record.
- old Q_w irrigation (Wahpeton to Rustad)	Subtract (-) the irrigation demand (Q_w) from Wahpeton to Rustad, developed for the Grand Forks (old) study, from the reference flow record.
+ new Q_r Union Stockyards	Add (+) the return flow (Q_r) from Union Stockyards, developed in the 1982 (new) study, to the referance flow record.

HEC-3 DATA ADJUSTMENTS

River	Location	Reference HEC-3 Flow Record	Adjustments
Red	Rustad	Control Point 14 RIV FLW (Red River at Wahpeton)	+ old Q_r Wahpeton - old Q_w irrigation (Wahpeton to Rustad) - old Q_w livestock (Wahpeton to Rustad)
Red	Briarwood Frontier	Control Point 13 INFLOW (Red River above Fargo-Moorhead)	- new Q_w Rustad + new Q_r Rustad, Sabin - new $(Q_w - Q_r)$ irrigation (Rustad to Briarwood) - old Q_w irrigation (Wahpeton to Rustad) - old Q_w livestock (Wahpeton to Briarwood) + old Q_r Wahpeton
Red	Fargo Moorhead Prairie Rose Dilworth	Control Point 13 INFLOW (Red River above Fargo-Moorhead)	+ 25 cfs when Sheyenne diversion required - new Q_w Rustad, Briarwood, Frontier + new Q_r Rustad, Briarwood, Frontier, Horace, Sabin - new $(Q_w - Q_r)$ irrigation (Rustad to Fargo) - old Q_w irrigation (Wahpeton to Rustad) - old Q_w livestock (Wahpeton to Fargo) + old Q_r Wahpeton
Red	North River Kragnes	Control Point 13 INFLOW (Red River above Fargo-Moorhead)	+ 25 cfs when Sheyenne diversion required - new Q_w Fargo, Moorhead (RRN portion), Rustad, Briarwood, Frontier, Prairie Rose + new Q_r Moorhead, Rustad, Briarwood, Frontier, Prairie Rose, Horace, Sabin - new Q_w American Crystal Sugar, Cass-Clay Creamery, Moorhead Power Plant - new $(Q_w - Q_r)$ irrigation (Rustad to North River) - old Q_w irrigaton (Wahpeton to Rustad) - old Q_w livestock (Wahpeton to North River) + old Q_r Wahpeton
Sheyenne	Horace	Control Point 9 INFLOW (Sheyenne River above diversion to Red River)	+ old Q_r Kindred - old Q_w irrigation (Kindred to Horace) - old Q_w livestock (Kindred to Horace)

HEC-3 DATA ADJUSTMENTS (continued)

River	Location	Reference HEC-3 Flow Record	Adjustments
Sheyenne	West Fargo Riverside	Control Point 10 INFLOW (Sheyenne River at West Fargo)	+ 25 cfs when Sheyenne diversion occurred in HEC-3 Run 16 - 25 cfs when Sheyenne diversion required - new Q_w Horace - new $(Q_w - Q_r)$ irrigation (Horace to West Fargo) - old Q_w irrigation (Kindred to Horace) - old Q_w livestock (Kindred to West Fargo) + old Q_r Kindred
Sheyenne	Reile's Acres Harwood Argusville	Control Point 10 INFLOW (Sheyenne River at West Fargo)	+ 25 cfs when Sheyenne diversion occurred in HEC-3 Run 16 - 25 cfs when Sheyenne diversion required + Maple River local flow from regional correlation analysis - new Q_w West Fargo, Riverside, Horace + new Q_r West Fargo, Riverside - new Q_w Cargill, Held Beef, Union Stockyards + new Q_r Union Stockyards - new $(Q_w - Q_r)$ irrigation (Horace to Maple River) - old Q_w irrigation (Kindred to Horace) - old Q_w livestock (Kindred to Maple River) + old Q_r Kindred
Buffalo	Dilworth Moorhead Glyndon Kragnes	Control Point 17 INFLOW (Buffalo River at Dilworth)	No adjustments required

HEC-3 DATA ADJUSTMENTS (continued)

Sheyenne Diversion Requirements

Diversion of 25 cfs from the Sheyenne River to the Red River is required if Red River inflow to control point 13 is less than the total of the following demands and return flows:

+ new Q_w Fargo, Moorhead (RRN portion), Rustad, Briarwood, Frontier, Prairie Rose
- new Q_r Rustad, Briarwood, Frontier, Sabin, Horace
+ new Q_w American Crystal Sugar, Cass-Clay Creamery, Moorhead Power Plant
+ new $(Q_w - Q_r)$ irrigation (Rustad to Fargo)
+ old Q_w irrigation (Wahpeton to Rustad)
+ old Q_w livestock (Wahpeton to Fargo)
- old Q_r Wahpeton

NOTE: Q_w = withdrawal; Q_r = return flow; "new" refers to specific year 2030 flow values documented in U.S. Army Corps of Engineers, St. Paul District, "Water Supply/ Conservation Investigations for the Fargo-Moorhead Urban Study Area, North Dakota and Minnesota - Phase 1, Part 1: Water Demand Projections," March 1982; "old" refers to specific year 2030 flow values which the Corps developed in 1976-77 and used in the HEC-3 model runs.

INITIAL HEC-4 STREAMFLOW CORRELATIONS

Tables B-1 through B-4 describe the relationships among the various streamflow records initially considered for reconstituting flows in the South Branch Buffalo River at Sabin (MN) and in the Maple River at Mapleton (ND). Tables B-1 and B-3 give the periods of record which exist and which were actually used in the analysis.

Table B-2 shows the initial correlation coefficients between the streamflow record of the South Branch Buffalo River and the other stream stations listed. Because the correlations with the Otter Tail River station were generally poorer than the others, this station was not used in the subsequent step of reconstituting South Branch Buffalo River flows.

Table B-4 shows the initial correlations between the Maple River at Mapleton record and the others listed. The Red River at Fargo was not used subsequently in reconstituting the Maple River at Mapleton flows because of its poorer correlation.

After reconstituting streamflows, the HEC-4 program produces final correlations among the stations used. These can be misleading and they are not included in this appendix. The reconstituting procedure enhances the correlations, so the final correlations can always be expected to be better (closer to +1.0) than the initial ones. The initial correlations therefore indicate the station interrelationships more objectively.

TABLE B-1

Stations and Records Used in Initial Correlations
South Branch Buffalo River at Sabin

Station	Period of Record Used	Existing Period of Record
Otter Tail River at Orwell Dam*	Oct '30 - Feb '53	Oct '30 - Oct '76+
Red River at Fargo*	Oct '29 - Feb '53	May '01 - Sep '76+
Wild Rice River (MN) at Twin Valley	Aug '30 - Sep '76	Aug '30 - Sep '76+
Buffalo River at Dilworth	Apr '31 - Sep '76	Apr '31 - Sep '76+
South Branch Buffalo at Sabin	Apr '45 - Sep '76	Apr '31 - Sep '76+

*Period of record used preceded construction of Orwell Dam.

TABLE B-2

Initial Correlation Coefficients
South Branch Buffalo River at Sabin

Month	Otter Tail	Red	Buffalo	Wild Rice (MN)
10	.610	.615	.758	.584
11	.706	.701	.789	.530
12	.355	.403	.680	.413
1	.836	.797	.639	.549
2	.859	.878	.335	.442
3	.030	.614	.932	.798
4	.489	.863	.971	.718
5	.389	.492	.877	.620
6	.600	.365	.968	.684
7	.179	.423	.947	.469
8	.217	.074	.803	.542
9	.674	.662	.858	.536
Average	.495	.574	.796	.574

TABLE B-3

Stations and Records Used in Initial Correlations
Maple River at Mapleton

Station	Period of Record Used	Existing Period of Record
Wild Rice River (ND) at Abercrombie	May '32 - Sep '76	May '32 - Sep '76+
Red River at Fargo*	Oct '29 - Feb '53	May '01 - Sep '76+
Sheyenne River at West Fargo**	Oct '29 - Jul '44	Sep '29 - Sep '76+
Maple River at Enderlin	Jun '56 - Sep '76	Jun '56 - Sep '76+
Goose River at Hillsboro	Apr '31 - Sep '76	Apr '31 - Sep '76+
Maple River at Mapleton	Apr '44 - Sep '75	Apr '44 - Sep ' 75

*Period of record used preceded construction of Orwell Dam.

**Period of record used preceded construction of Baldhill Dam.

TABLE B-4

Initial Correlation Coefficients
Maple River at Mapleton

Month	Wild Rice (ND)	Red	Sheyenne	Maple (at Enderlin)	Goose
10	.537	.433	.882	.722	.774
11	.521	.583	.962	.849	.690
12	.619	.482	.846	.816	.658
1	.495	.252	.186	.632	.460
2	.554	.068	-.201	.510	.508
3	.817	.582	.646	.811	.815
4	.839	.749	.816	.986	.887
5	.728	.706	.386	.966	.880
6	.650	.495	.447	.807	.590
7	.568	.550	.742	.933	.668
8	.553	.101	.673	.895	.454
9	.547	.321	.634	.668	.673
Average	.619	.444	.585	.800	.671

FARGO-MOORHEAD URBAN STUDY

WATER SUPPLY

PHASE 1, PART 2, APPENDIX C

RESULTS OF PARTIAL DURATION ANALYSES

RESULTS OF PARTIAL DURATION ANALYSES

In performing the partial duration analyses, several assumptions were made.

The assumptions for the year 2030 case are:

1. Year 2030 projected water demands.

2. Reservoirs operated under current regulatory policies.

3. Lake Ashtabula (Baldhill Dam) and Orwell Reservoir operated to satisfy Fargo-Moorhead's water demands.

The assumptions for the year 1980 analyses are the same except that year 1980 projected demands are used in place of those projected for year 2030.

In both analyses, the data for the partial duration analyses were derived from the HEC-3 computer program, "Reservoir Analysis for Conservation."

RESULTS OF YEAR 2030 PARTIAL DURATION ANALYSES

Sheyenne River at Horace - Year 2030 Case

SHEYENNE RIVER AT HORACE

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	842.	7.0	1.47	68.2	8 1961	2.84
2	877.	7.3	3.58	27.9	6 1934	2.13
3	881.	7.3	5.69	17.6	9 1937	1.76
4	896.	7.4	7.81	12.8	3 1941	1.51
5	942.	7.8	9.92	10.1	9 1967	1.31
6	1240.	10.3	12.04	8.3	7 1938	1.15
7	1244.	10.3	14.15	7.1	9 1959	1.02
8	1364.	11.3	16.26	6.1	9 1952	.90
9	1425.	11.8	18.38	5.4	9 1958	.79
10	1439.	11.9	20.49	4.9	1 1939	.70
11	1560.	12.9	22.61	4.4	11 1937	.61
12	1620.	13.4	24.72	4.0	2 1936	.53
13	1663.	13.8	26.83	3.7	7 1939	.46
14	1666.	13.8	28.95	3.5	9 1968	.39
15	1808.	15.0	31.06	3.2	8 1973	.32
16	1869.	15.5	33.18	3.0	8 1946	.26
17	1922.	15.9	35.29	2.8	1 1962	.20
18	1965.	16.3	37.40	2.7	7 1940	.14
19	1968.	16.3	39.52	2.5	9 1960	.09
20	1989.	16.5	41.63	2.4	8 1930	.03
21	2110.	17.5	43.75	2.3	8 1941	-.02
22	2149.	17.8	45.86	2.2	9 1947	-.07
23	2210.	18.3	47.97	2.1	9 1974	-.12
24	2270.	18.8	50.09	2.0	9 1956	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	1354.	7.5	1.47	68.1	9 1961	2.83
2	1595.	8.8	3.59	27.9	9 1937	2.13
3	1917.	10.6	5.70	17.5	3 1941	1.76
4	2078.	11.5	7.82	12.8	9 1958	1.51
5	2219.	12.3	9.94	10.1	2 1939	1.31
6	2400.	13.3	12.06	8.3	12 1937	1.15
7	2501.	13.8	14.18	7.1	9 1967	1.01
8	2742.	15.1	16.29	6.1	9 1959	.90
9	3059.	16.9	18.41	5.4	8 1938	.79
10	3161.	17.4	20.53	4.9	7 1934	.70
11	3165.	17.5	22.65	4.4	9 1973	.61
12	3306.	18.3	24.76	4.0	1 1962	.53
13	3548.	19.6	26.88	3.7	2 1936	.46
14	3648.	20.1	29.00	3.4	9 1946	.39
15	3663.	20.2	31.12	3.2	8 1939	.32
16	3829.	21.1	33.23	3.0	9 1947	.26
17	3889.	21.5	35.35	2.8	9 1963	.20
18	3950.	21.8	37.47	2.7	9 1945	.14
19	3965.	21.9	39.59	2.5	8 1940	.08
20	4003.	22.1	41.71	2.4	11 1938	.03
21	4010.	22.1	43.82	2.3	9 1960	-.02
22	4131.	22.8	45.94	2.2	9 1930	-.07
23	4372.	24.1	48.06	2.1	9 1931	-.12
24	4433.	24.5	50.18	2.0	9 1974	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2435.	10.1	1.47	67.9	10 1937	2.83
2	3329.	13.8	3.59	27.8	9 1961	2.13
3	3362.	13.9	5.71	17.5	2 1939	1.76
4	3643.	15.1	7.84	12.8	10 1958	1.50
5	3663.	15.2	9.96	10.0	3 1941	1.31
6	4207.	17.4	12.08	8.3	2 1938	1.15
7	4373.	18.1	14.20	7.0	11 1959	1.01
8	4778.	19.8	16.32	6.1	9 1938	.89
9	4856.	20.1	18.44	5.4	11 1973	.79
10	5100.	21.1	20.56	4.9	8 1934	.70
11	5294.	21.9	22.69	4.4	1 1962	.61
12	5454.	22.6	24.81	4.0	10 1967	.53
13	5475.	22.7	26.93	3.7	2 1936	.45
14	5502.	22.8	29.05	3.4	9 1939	.38
15	5810.	24.1	31.17	3.2	12 1963	.32
16	5925.	24.5	33.29	3.0	9 1940	.25
17	6179.	25.6	35.42	2.8	10 1930	.20
18	6429.	26.6	37.54	2.7	8 1931	.14
19	6561.	27.2	39.66	2.5	4 1937	.08
20	6622.	27.4	41.78	2.4	3 1940	.03
21	7225.	29.9	43.90	2.3	1 1932	-.02
22	7386.	30.6	46.02	2.2	10 1935	-.07
23	7588.	31.4	48.14	2.1	3 1934	-.12
24	7809.	32.3	50.27	2.0	10 1933	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	3995.	11.0	1.48	67.7	12 1937	2.83
2	5686.	15.7	3.61	27.7	12 1961	2.13
3	6223.	17.2	5.73	17.4	2 1939	1.76
4	8342.	23.0	7.86	12.7	12 1963	1.50
5	8451.	23.3	9.99	10.0	11 1973	1.31
6	8632.	23.8	12.12	8.2	11 1959	1.15
7	8988.	24.8	14.25	7.0	10 1934	1.01
8	9719.	26.8	16.38	6.1	11 1939	.89
9	9785.	27.0	18.51	5.4	2 1936	.79
10	10270.	28.4	20.64	4.8	7 1940	.69
11	10455.	28.9	22.77	4.4	12 1931	.61
12	10597.	29.3	24.90	4.0	4 1937	.53
13	11844.	32.7	27.02	3.7	12 1933	.45
14	11960.	33.0	29.15	3.4	7 1938	.38
15	12006.	33.1	31.28	3.2	10 1958	.31
16	13462.	37.2	33.41	3.0	11 1932	.25
17	14038.	38.8	35.54	2.8	3 1941	.19
18	15406.	42.5	37.67	2.7	12 1930	.13
19	15568.	43.0	39.80	2.5	10 1936	.08
20	17540.	48.4	41.93	2.4	4 1935	.03
21	19158.	52.9	44.06	2.3	8 1957	-.03
22	19813.	54.7	46.19	2.2	12 1967	-.08
23	23677.	65.4	48.31	2.1	12 1960	-.13
24	25235.	69.7	50.44	2.0	11 1945	-.17

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	9282.	17.1	1.48	67.3	2 1939	2.83
2	10368.	19.1	3.63	27.6	2 1938	2.12
3	12113.	22.3	5.77	17.3	1 1962	1.75
4	15150.	27.9	7.91	12.6	3 1940	1.50
5	15150.	27.9	10.05	10.0	3 1936	1.30
6	15192.	28.0	12.19	8.2	1 1935	1.14
7	15554.	28.6	14.33	7.0	1 1932	1.01
8	16545.	30.4	16.47	6.1	4 1937	.89
9	17625.	32.4	18.61	5.4	3 1934	.78
10	18169.	33.4	20.75	4.8	3 1941	.69
11	19840.	36.5	22.89	4.4	11 1959	.60
12	21308.	39.2	25.03	4.0	3 1964	.52
13	23825.	43.8	27.17	3.7	1 1974	.45
14	28353.	52.2	29.31	3.4	12 1932	.38
15	29621.	54.5	31.45	3.2	1 1959	.31
16	33685.	62.0	33.59	3.0	3 1931	.25
17	39247.	72.2	35.73	2.8	8 1957	.19
18	41533.	76.4	37.87	2.6	3 1968	.13
19	41895.	77.1	40.01	2.5	3 1948	.07
20	43163.	79.4	42.15	2.4	3 1946	.02
21	43163.	79.4	44.29	2.3	3 1975	-.03
22	43465.	80.0	46.43	2.2	3 1956	-.08
23	44552.	82.0	48.57	2.1	3 1947	-.13
24	46182.	85.0	50.71	2.0	3 1961	-.18

(continued)

1

YEARS (RECORD) MONTHS 47 0 — DURATION IN MONTHS 12

EFFECTIVE YEARS 46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	15781.	21.8	1.49	67.0	2 1938	2.82
2	18196.	25.1	3.64	27.4	3 1939	2.12
3	21516.	29.7	5.80	17.3	4 1940	1.75
4	25682.	35.4	7.95	12.6	6 1934	1.49
5	27674.	38.2	10.10	9.9	4 1936	1.30
6	28701.	39.6	12.25	8.2	3 1962	1.14
7	29365.	40.5	14.40	6.9	2 1932	1.00
8	34859.	48.1	16.56	6.0	12 1959	.88
9	39809.	54.9	18.71	5.3	6 1964	.78
10	41862.	57.8	20.86	4.8	4 1941	.68
11	43069.	59.4	23.01	4.3	3 1974	.60
12	47839.	66.0	25.16	4.0	2 1933	.52
13	57438.	79.3	27.32	3.7	8 1957	.44
14	58465.	80.7	29.47	3.4	12 1958	.37
15	70177.	96.9	31.62	3.2	6 1968	.30
16	71928.	99.3	33.77	3.0	5 1953	.24
17	75007.	103.5	35.92	2.8	3 1946	.18
18	77542.	107.0	38.07	2.6	5 1954	.12
19	77965.	107.6	40.23	2.5	3 1956	.07
20	82252.	113.5	42.38	2.4	3 1947	.01
21	82312.	113.6	44.53	2.2	8 1944	-.04
22	84244.	116.3	46.68	2.1	4 1942	-.09
23	98552.	136.0	48.83	2.0	2 1931	-.14
24	105616.	145.8	50.99	2.0	3 1948	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	34882.	24.1	1.53	65.5	2 1939	2.81
2	52753.	36.4	3.72	26.8	3 1941	2.10
3	54202.	37.4	5.92	16.9	4 1936	1.73
4	77204.	53.3	8.12	12.3	2 1933	1.47
5	85052.	58.7	10.32	9.7	3 1960	1.28
6	121216.	83.7	12.52	8.0	3 1965	1.12
7	129306.	89.2	14.72	6.8	4 1962	.98
8	149470.	103.2	16.92	5.9	5 1954	.86
9	157258.	108.5	19.12	5.2	3 1947	.76
10	179476.	123.9	21.32	4.7	8 1957	.66
11	194690.	134.4	23.52	4.3	3 1943	.58
12	202297.	139.6	25.72	3.9	3 1974	.50
13	241479.	166.7	27.92	3.6	3 1969	.42
14	303542.	209.5	30.12	3.3	5 1971	.35
15	308070.	212.6	32.31	3.1	3 1945	.28
16	331917.	229.1	34.51	2.9	3 1949	.22
17	368624.	254.4	36.71	2.7	5 1952	.16
18	438234.	302.4	38.91	2.6	7 1976	.10
19	460572.	317.9	41.11	2.4	3 1967	.05

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	86367.	29.8	1.60	62.7	7 1940	2.77
2	144748.	49.9	3.90	25.7	4 1936	2.06
3	235911.	81.4	6.20	16.1	3 1962	1.69
4	351827.	121.4	8.50	11.8	4 1956	1.44
5	354121.	122.2	10.80	9.3	3 1948	1.24
6	538319.	185.8	13.10	7.6	2 1974	1.08
7	570257.	196.8	15.40	6.5	12 1966	.94
8	906957.	313.0	17.70	5.7	4 1952	.83

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	208837.	36.0	1.76	56.9	3 1941	2.69
2	639237.	110.3	4.29	23.3	2 1962	1.99
3	991936.	171.1	6.82	14.7	3 1949	1.62
4	1269772.	219.1	9.36	10.7	12 1970	1.36

INDEPENDENT EVENTS EXHAUSTED

Sheyenne River at West Fargo - Year 2030 Case

SHEYENNE RIVER AT WEST FARGO / RIVERSIDE

YEARS (RECORD) MONTHS DURATION IN MONTHS

47 0 2

EFFECTIVE YEARS

46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL.K
1	813.	6.7	1.47	68.2	1 1935	2.84
2	933.	7.7	3.58	27.9	2 1937	2.13
3	1054.	8.7	5.69	17.6	3 1941	1.76
4	1115.	9.2	7.81	12.8	8 1961	1.51
5	1212.	10.0	9.92	10.1	6 1934	1.31
6	1236.	10.2	12.04	8.3	8 1937	1.15
7	1580.	13.1	14.15	7.1	9 1952	1.02
8	1597.	13.2	16.26	6.1	2 1936	.90
9	1628.	13.5	18.38	5.4	10 1937	.79
10	1657.	13.7	20.49	4.9	12 1937	.70
11	1838.	15.2	22.61	4.4	2 1939	.61
12	1882.	15.6	24.72	4.0	9 1959	.53
13	2080.	17.2	26.83	3.7	12 1938	.46
14	2081.	17.2	28.95	3.5	1 1962	.39
15	2244.	18.6	31.06	3.2	9 1960	.32
16	2304.	19.1	33.18	3.0	9 1968	.26
17	2382.	19.7	35.29	2.8	12 1936	.20
18	2425.	20.1	37.40	2.7	9 1970	.14
19	2441.	20.2	39.52	2.5	4 1940	.09
20	2442.	20.2	41.63	2.4	3 1935	.03
21	2478.	20.5	43.75	2.3	7 1938	-.02
22	2562.	21.2	45.86	2.2	4 1937	-.07
23	2606.	21.6	47.97	2.1	9 1967	-.12
24	2623.	21.7	50.09	2.0	12 1963	-.17

1

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	1279.	7.1	1.47	68.1	2 1935	2.83
2	1400.	7.7	3.59	27.9	2 1937	2.13
3	1735.	9.6	5.70	17.5	9 1961	1.76
4	2036.	11.2	7.82	12.8	9 1937	1.51
5	2184.	12.1	9.94	10.1	3 1941	1.31
6	2484.	13.7	12.06	8.3	12 1937	1.15
7	2728.	15.1	14.18	7.1	2 1939	1.01
8	3299.	18.2	16.29	6.1	7 1934	.90
9	3392.	18.7	18.41	5.4	3 1936	.79
10	3573.	19.7	20.53	4.9	1 1962	.70
11	3735.	20.6	22.65	4.4	10 1959	.61
12	4267.	23.6	24.76	4.0	11 1938	.53
13	4270.	23.6	26.88	3.7	9 1963	.46
14	4270.	23.6	29.00	3.4	9 1960	.39
15	4417.	24.4	31.12	3.2	4 1940	.32
16	4580.	25.3	33.23	3.0	10 1958	.26
17	4693.	25.9	35.35	2.8	9 1945	.20
18	4693.	25.9	37.47	2.7	9 1939	.14
19	4693.	25.9	39.59	2.5	9 1940	.08
20	4693.	25.9	41.71	2.4	9 1931	.03
21	4707.	26.0	43.82	2.3	8 1938	-.02
22	4718.	26.0	45.94	2.2	12 1963	-.07
23	4934.	27.2	48.06	2.1	9 1976	-.12
24	5176.	28.6	50.18	2.0	9 1946	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2712.	11.2	1.47	67.9	3 1937	2.83
2	2863.	11.9	3.59	27.8	10 1937	2.13
3	3255.	13.5	5.71	17.5	3 1935	1.76
4	3918.	16.2	7.84	12.8	2 1939	1.50
5	3950.	16.4	9.96	10.0	10 1961	1.31
6	4221.	17.5	12.08	8.3	3 1941	1.15
7	4763.	19.7	14.20	7.0	2 1938	1.01
8	4804.	19.9	16.32	6.1	11 1959	.89
9	5308.	22.0	18.44	5.4	3 1936	.79
10	5346.	22.1	20.56	4.9	8 1934	.70
11	5822.	24.1	22.69	4.4	10 1938	.61
12	6122.	25.4	24.81	4.0	12 1963	.53
13	6393.	26.5	26.93	3.7	4 1940	.45
14	6667.	27.6	29.05	3.4	10 1940	.38
15	6667.	27.6	31.17	3.2	10 1939	.32
16	6727.	27.9	33.29	3.0	10 1958	.25
17	6727.	27.9	35.42	2.8	10 1931	.20
18	7210.	29.9	37.54	2.7	10 1930	.14
19	7944.	32.9	39.66	2.5	11 1936	.08
20	7962.	33.0	41.78	2.4	1 1934	.03
21	8065.	33.4	43.90	2.3	11 1932	-.02
22	8297.	34.4	46.02	2.2	10 1967	-.07
23	8729.	36.1	48.14	2.1	11 1935	-.12
24	9625.	39.9	50.27	2.0	10 1960	-.17

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4521.	12.5	1.48	67.7	12 1937	2.83
2	5877.	16.2	3.61	27.7	4 1937	2.13
3	6513.	18.0	5.73	17.4	12 1961	1.76
4	6995.	19.3	7.86	12.7	2 1939	1.50
5	7325.	20.2	9.99	10.0	3 1935	1.31
6	8231.	22.7	12.12	8.2	3 1941	1.15
7	8988.	24.8	14.25	7.0	12 1963	1.01
8	9136.	25.2	16.38	6.1	3 1936	.89
9	10317.	28.5	18.51	5.4	12 1959	.79
10	10405.	28.7	20.64	4.8	4 1940	.69
11	10618.	29.3	22.77	4.4	12 1931	.61
12	11945.	33.0	24.90	4.0	2 1934	.53
13	12166.	33.6	27.02	3.7	10 1939	.45
14	14422.	39.8	29.15	3.4	12 1932	.38
15	14521.	40.1	31.28	3.2	9 1934	.31
16	15202.	42.0	33.41	3.0	7 1938	.25
17	15969.	44.1	35.54	2.8	10 1958	.19
18	16822.	46.4	37.67	2.7	11 1930	.13
19	18565.	51.3	39.80	2.5	10 1936	.08
20	23275.	64.3	41.93	2.4	9 1935	.03
21	23303.	64.3	44.06	2.3	8 1957	-.03
22	23417.	64.6	46.19	2.2	12 1967	-.08
23	24142.	66.6	48.31	2.1	12 1960	-.13
24	26446.	73.0	50.44	2.0	1 1974	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	10554.	19.4	1.48	67.3	2 1938	2.83
2	11701.	21.5	3.63	27.6	2 1939	2.12
3	11906.	21.9	5.77	17.3	4 1937	1.75
4	11943.	22.0	7.91	12.6	2 1935	1.50
5	12923.	23.8	10.05	10.0	3 1941	1.30
6	13927.	25.6	12.19	8.2	1 1962	1.14
7	15278.	28.1	14.33	7.0	3 1940	1.01
8	16968.	31.2	16.47	6.1	3 1936	.89
9	19120.	35.2	18.61	5.4	1 1932	.78
10	19142.	35.2	20.75	4.8	3 1934	.69
11	23066.	42.5	22.89	4.4	3 1964	.60
12	24974.	46.0	25.03	4.0	12 1959	.52
13	29262.	53.9	27.17	3.7	1 1933	.45
14	33971.	62.5	29.31	3.4	1 1959	.38
15	38461.	70.8	31.45	3.2	3 1931	.31
16	43117.	79.4	33.59	3.0	8 1957	.25
17	44680.	82.2	35.73	2.8	3 1946	.19
18	45585.	83.9	37.87	2.6	3 1975	.13
19	45887.	84.5	40.01	2.5	3 1968	.07
20	45887.	84.5	42.15	2.4	3 1956	.02
21	45947.	84.6	44.29	2.3	3 1974	-.03
22	47517.	87.5	46.43	2.2	3 1948	-.08
23	47578.	87.6	48.57	2.1	3 1961	-.13
24	50596.	93.1	50.71	2.0	3 1947	-.18

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	13514.	18.7	1.49	67.0	11 1937	2.82
2	20156.	27.8	3.64	27.4	3 1941	2.12
3	21846.	30.2	5.80	17.3	3 1935	1.75
4	23355.	32.2	7.95	12.6	2 1939	1.49
5	26917.	37.2	10.10	9.9	3 1962	1.30
6	30238.	41.7	12.25	8.2	3 1940	1.14
7	31083.	42.9	14.40	6.9	4 1936	1.00
8	36637.	50.6	16.56	6.0	2 1932	.88
9	40441.	55.8	18.71	5.3	12 1959	.78
10	42252.	58.3	20.86	4.8	3 1934	.68
11	43701.	60.3	23.01	4.3	6 1964	.60
12	61209.	84.5	25.16	4.0	7 1957	.52
13	61873.	85.4	27.32	3.7	2 1933	.44
14	64167.	88.6	29.47	3.4	12 1958	.37
15	75155.	103.7	31.62	3.2	6 1968	.30
16	81494.	112.5	33.77	3.0	3 1946	.24
17	82038.	113.2	35.92	2.8	3 1956	.18
18	82642.	114.1	38.07	2.6	5 1953	.12
19	83125.	114.7	40.23	2.5	6 1954	.07
20	91215.	125.9	42.38	2.4	4 1942	.01
21	98580.	136.1	44.53	2.2	3 1947	-.04
22	100029.	138.1	46.68	2.1	7 1944	-.09
23	111983.	154.6	48.83	2.0	3 1974	-.14
24	117477.	162.2	50.99	2.0	12 1960	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	38077.	26.3	1.53	65.5	11 1938	2.81
2	50393.	34.8	3.72	26.8	3 1941	2.10
3	53835.	37.2	5.92	16.9	4 1936	1.73
4	95613.	66.0	8.12	12.3	3 1960	1.47
5	98511.	68.0	10.32	9.7	2 1933	1.28
6	128214.	88.5	12.52	8.0	3 1965	1.12
7	130931.	90.4	14.72	6.8	4 1962	.98
8	176211.	121.6	16.92	5.9	5 1954	.86
9	180075.	124.3	19.12	5.2	3 1947	.76
10	185327.	127.9	21.32	4.7	8 1957	.66
11	211589.	146.0	23.52	4.3	3 1943	.58
12	256205.	176.8	25.72	3.9	3 1969	.50
13	318812.	220.0	27.92	3.6	9 1971	.42
14	329377.	227.3	30.12	3.3	3 1975	.35
15	354130.	244.4	32.31	3.1	3 1945	.28
16	369042.	254.7	34.51	2.9	4 1949	.22
17	375562.	259.2	36.71	2.7	5 1952	.16
18	469382.	323.9	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	90825.	31.3	1.60	62.7	7 1940	2.77
2	160254.	55.3	3.90	25.7	7 1936	2.06
3	245803.	84.8	6.20	16.1	3 1962	1.69
4	374518.	129.2	8.50	11.8	8 1957	1.44
5	424748.	146.6	10.80	9.3	3 1948	1.24
6	590532.	203.8	13.10	7.6	12 1966	1.08
7	669198.	230.9	15.40	6.5	5 1971	.94
8	782156.	269.9	17.70	5.7	5 1953	.83
9	798517.	275.5	20.00	5.0	5 1975	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	218900.	37.8	1.76	56.9	3 1941	2.69
2	659503.	113.8	4.29	23.3	3 1962	1.99
3	1131257.	195.2	6.82	14.7	3 1949	1.62
4	1287201.	222.1	9.36	10.7	12 1970	1.36

INDEPENDENT EVENTS EXHAUSTED

1

READY.

Sheyenne River at Reile's Acres - Year 2030 Case

SHEYENNE RIVER AT REILE'S ACRES / HARWOOD / ARGUSVILLE

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	490.	4.1	1.47	68.2	2 1937	2.84
2	550.	4.6	3.58	27.9	2 1935	2.13
3	966.	8.0	5.69	17.6	8 1961	1.76
4	1335.	11.1	7.81	12.8	2 1941	1.51
5	1335.	11.1	9.92	10.1	2 1936	1.31
6	1456.	12.1	12.04	8.3	2 1939	1.15
7	1491.	12.3	14.15	7.1	9 1937	1.02
8	1552.	12.8	16.26	6.1	9 1952	.90
9	1853.	15.3	18.38	5.4	9 1959	.79
10	1980.	16.4	20.49	4.9	1 1962	.70
11	2009.	16.6	22.61	4.4	11 1937	.61
12	2155.	17.8	24.72	4.0	9 1960	.53
13	2204.	18.3	26.83	3.7	3 1940	.46
14	2285.	18.9	28.95	3.5	12 1938	.39
15	2475.	20.5	31.06	3.2	8 1931	.32
16	2587.	21.4	33.18	3.0	12 1936	.26
17	2638.	21.8	35.29	2.8	9 1967	.20
18	2638.	21.8	37.40	2.7	9 1956	.14
19	2656.	22.0	39.52	2.5	8 1939	.09
20	2663.	22.1	41.63	2.4	2 1938	.03
21	2717.	22.5	43.75	2.3	8 1940	-.02
22	2717.	22.5	45.86	2.2	8 1938	-.07
23	2768.	22.9	47.97	2.1	12 1934	-.12
24	2777.	23.0	50.09	2.0	8 1946	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS

47   0   3

EFFECTIVE YEARS

46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	997.	5.5	1.47	68.1	2 1937	2.83
2	1058.	5.8	3.59	27.9	2 1935	2.13
3	1867.	10.3	5.70	17.5	9 1961	1.76
4	2386.	13.2	7.82	12.8	2 1939	1.51
5	2387.	13.2	9.94	10.1	10 1937	1.31
6	3012.	16.6	12.06	8.3	3 1936	1.15
7	3072.	17.0	14.18	7.1	3 1941	1.01
8	3576.	19.7	16.29	6.1	1 1962	.90
9	3593.	19.8	18.41	5.4	2 1938	.79
10	3715.	20.5	20.53	4.9	10 1959	.70
11	3978.	22.0	22.65	4.4	3 1940	.61
12	4282.	23.6	24.76	4.0	9 1960	.53
13	4420.	24.4	26.88	3.7	11 1938	.46
14	4705.	26.0	29.00	3.4	9 1939	.39
15	4765.	26.3	31.12	3.2	9 1940	.32
16	4765.	26.3	33.23	3.0	9 1931	.26
17	5007.	27.6	35.35	2.8	9 1945	.20
18	5044.	27.8	37.47	2.7	10 1958	.14
19	5113.	28.2	39.59	2.5	12 1963	.08
20	5309.	29.3	41.71	2.4	9 1946	.03
21	5465.	30.2	43.82	2.3	2 1934	-.02
22	5466.	30.2	45.94	2.2	10 1952	-.07
23	5647.	31.2	48.06	2.1	10 1967	-.12
24	5656.	31.2	50.18	2.0	12 1935	-.17

(continued)

YEARS (RECORD) MONTHS 47 0 DURATION IN MONTHS 4

EFFECTIVE YEARS 46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2192.	9.1	1.47	67.9	3 1937	2.83
2	3307.	13.7	3.59	27.8	10 1937	2.13
3	3318.	13.7	5.71	17.5	2 1935	1.76
4	3741.	15.5	7.84	12.8	2 1939	1.50
5	4266.	17.7	9.96	10.0	9 1961	1.31
6	4707.	19.5	12.08	8.3	2 1938	1.15
7	4829.	20.0	14.20	7.0	11 1959	1.01
8	4969.	20.6	16.32	6.1	3 1936	.89
9	5089.	21.1	18.44	5.4	3 1941	.79
10	5782.	23.9	20.56	4.9	10 1938	.70
11	5935.	24.6	22.69	4.4	3 1940	.61
12	6627.	27.4	24.81	4.0	10 1939	.53
13	6688.	27.7	26.93	3.7	10 1940	.45
14	6920.	28.7	29.05	3.4	12 1963	.38
15	6929.	28.7	31.17	3.2	10 1931	.32
16	7128.	29.5	33.29	3.0	1 1962	.25
17	7423.	30.7	35.42	2.8	2 1934	.20
18	7895.	32.7	37.54	2.7	10 1930	.14
19	8149.	33.7	39.66	2.5	11 1936	.08
20	8270.	34.2	41.78	2.4	11 1932	.03
21	8511.	35.2	43.90	2.3	11 1935	-.02
22	8740.	36.2	46.02	2.2	8 1934	-.07
23	8861.	36.7	48.14	2.1	10 1967	-.12
24	9042.	37.4	50.27	2.0	10 1933	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	5350.	14.8	1.48	67.7	12 1937	2.83
2	6253.	17.3	3.61	27.7	3 1937	2.13
3	6806.	18.8	5.73	17.4	2 1939	1.76
4	7530.	20.8	7.86	12.7	2 1935	1.50
5	8188.	22.6	9.99	10.0	12 1961	1.31
6	8668.	23.9	12.12	8.2	3 1936	1.15
7	9031.	24.9	14.25	7.0	3 1941	1.01
8	9815.	27.1	16.38	6.1	3 1940	.89
9	10793.	29.8	18.51	5.4	1 1964	.79
10	11086.	30.6	20.64	4.8	12 1931	.69
11	11325.	31.3	22.77	4.4	3 1934	.61
12	11629.	32.1	24.90	4.0	12 1959	.53
13	14708.	40.6	27.02	3.7	12 1932	.45
14	17867.	49.3	29.15	3.4	11 1930	.38
15	19671.	54.3	31.28	3.2	7 1938	.31
16	20861.	57.6	33.41	3.0	10 1958	.25
17	21494.	59.3	35.54	2.8	9 1940	.19
18	21977.	60.7	37.67	2.7	9 1939	.13
19	24006.	66.3	39.80	2.5	12 1960	.08
20	24307.	67.1	41.93	2.4	12 1967	.03
21	26686.	73.7	44.06	2.3	9 1935	-.03
22	26961.	74.4	46.19	2.2	3 1974	-.08
23	27930.	77.1	48.31	2.1	12 1945	-.13
24	29327.	81.0	50.44	2.0	1 1953	-.17

1

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	11861.	21.8	1.48	67.3	2 1938	2.83
2	12646.	23.3	3.63	27.6	2 1939	2.12
3	12649.	23.3	5.77	17.3	3 1937	1.75
4	13796.	25.4	7.91	12.6	3 1941	1.50
5	14520.	26.7	10.05	10.0	3 1940	1.30
6	15423.	28.4	12.19	8.2	2 1935	1.14
7	16211.	29.8	14.33	7.0	3 1962	1.01
8	16694.	30.7	16.47	6.1	3 1936	.89
9	18445.	33.9	18.61	5.4	3 1934	.78
10	20754.	38.2	20.75	4.8	1 1932	.69
11	24603.	45.3	22.89	4.4	3 1964	.60
12	30577.	56.3	25.03	4.0	2 1933	.52
13	32874.	60.5	27.17	3.7	3 1960	.45
14	37221.	68.5	29.31	3.4	3 1959	.38
15	40478.	74.5	31.45	3.2	2 1931	.31
16	47242.	86.9	33.59	3.0	3 1974	.25
17	48390.	89.1	35.73	2.8	3 1975	.19
18	48571.	89.4	37.87	2.6	3 1961	.13
19	48933.	90.1	40.01	2.5	3 1968	.07
20	49356.	90.8	42.15	2.4	3 1948	.02
21	49537.	91.2	44.29	2.3	3 1956	-.03
22	49718.	91.5	46.43	2.2	3 1957	-.08
23	51408.	94.6	48.57	2.1	3 1946	-.13
24	53829.	99.1	50.71	2.0	4 1953	-.18

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	18510.	25.5	1.49	67.0	11 1937	2.82
2	27385.	37.8	3.64	27.4	2 1935	2.12
3	27747.	38.3	5.80	17.3	2 1939	1.75
4	29257.	40.4	7.95	12.6	2 1941	1.49
5	29981.	41.4	10.10	9.9	3 1962	1.30
6	35354.	48.8	12.25	8.2	3 1936	1.14
7	42418.	58.5	14.40	6.9	2 1940	1.00
8	49602.	68.5	16.56	6.0	12 1959	.88
9	49784.	68.7	18.71	5.3	3 1932	.78
10	57028.	78.7	20.86	4.8	6 1964	.68
11	67594.	93.3	23.01	4.3	7 1957	.60
12	69526.	96.0	25.16	4.0	2 1934	.52
13	74899.	103.4	27.32	3.7	12 1958	.44
14	90596.	125.0	29.47	3.4	6 1968	.37
15	92407.	127.5	31.62	3.2	4 1953	.30
16	93735.	129.4	33.77	3.0	3 1956	.24
17	95667.	132.0	35.92	2.8	3 1946	.18
18	95848.	132.3	38.07	2.6	6 1954	.12
19	102368.	141.3	40.23	2.5	3 1931	.07
20	103334.	142.6	42.38	2.4	4 1942	.01
21	109794.	151.5	44.53	2.2	3 1947	-.04
22	110881.	153.0	46.68	2.1	8 1944	-.09
23	119816.	165.4	48.83	2.0	3 1974	-.14
24	143784.	198.5	50.99	2.0	12 1960	-.19

(continued)

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	47465.	32.8	1.53	65.5	11 1938	2.81
2	62317.	43.0	3.72	26.8	3 1941	2.10
3	63826.	44.0	5.92	16.9	3 1936	1.73
4	117679.	81.2	8.12	12.3	3 1960	1.47
5	129029.	89.0	10.32	9.7	2 1933	1.28
6	156801.	108.2	12.52	8.0	3 1965	1.12
7	177086.	122.2	14.72	6.8	3 1962	.98
8	193870.	133.8	16.92	5.9	3 1956	.86
9	205461.	141.8	19.12	5.2	3 1947	.76
10	254182.	175.4	21.32	4.7	3 1943	.66
11	256960.	177.3	23.52	4.3	3 1958	.58
12	299523.	206.7	25.72	3.9	5 1953	.50
13	309786.	213.8	27.92	3.6	3 1969	.42
14	386822.	267.0	30.12	3.3	3 1975	.35
15	391893.	270.5	32.31	3.1	3 1945	.28
16	435603.	300.6	34.51	2.9	6 1949	.22
17	442788.	305.6	36.71	2.7	9 1971	.16
18	669730.	462.2	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

```
1
 YEARS (RECORD) MONTHS      DURATION IN MONTHS
   47              0                48

 EFFECTIVE YEARS
      43.08
```

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	118174.	40.8	1.60	62.7	11 1940	2.77
2	185913.	64.2	3.90	25.7	9 1936	2.06
3	294765.	101.7	6.20	16.1	3 1962	1.69
4	409353.	141.3	8.50	11.8	8 1957	1.44
5	550143.	189.8	10.80	9.3	3 1948	1.24
6	815543.	281.4	13.10	7.6	12 1966	1.08
7	939609.	324.2	15.40	6.5	3 1974	.94
8	974143.	336.2	17.70	5.7	5 1953	.83

```
 INDEPENDENT EVENTS EXHAUSTED
1
 YEARS (RECORD) MONTHS      DURATION IN MONTHS
   47              0                96

 EFFECTIVE YEARS
      39.08
```

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	272089.	46.9	1.76	56.9	3 1941	2.69
2	745594.	128.6	4.29	23.3	3 1962	1.99
3	1357535.	234.2	6.82	14.7	3 1949	1.62
4	1805382.	311.5	9.36	10.7	12 1970	1.36

```
 INDEPENDENT EVENTS EXHAUSTED
1
READY.
```

Maple River at Mapleton - Year 2030 and Year 1980 Cases

MAPLE RIVER AT MAPLETON

YEARS (RECORD) MONTHS DURATION IN MONTHS

47 0 2

EFFECTIVE YEARS

46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	0	0	1.47	68.2	8 1931	2.84
2	0	0	3.58	27.9	2 1933	2.13
3	0	0	5.69	17.6	10 1933	1.76
4	0	0	7.81	12.8	12 1933	1.51
5	0	0	9.92	10.1	2 1934	1.31
6	0	0	12.04	8.3	9 1935	1.15
7	0	0	14.15	7.1	11 1935	1.02
8	0	0	16.26	6.1	2 1937	.90
9	0	0	18.38	5.4	2 1938	.79
10	0	0	20.49	4.9	9 1938	.70
11	0	0	22.61	4.4	10 1939	.61
12	0	0	24.72	4.0	12 1939	.53
13	0	0	26.83	3.7	2 1940	.46
14	0	0	28.95	3.5	10 1940	.39
15	0	0	31.06	3.2	1 1941	.32
16	0	0	33.18	3.0	2 1944	.26
17	0	0	35.29	2.8	2 1945	.20
18	0	0	37.40	2.7	2 1946	.14
19	0	0	39.52	2.5	9 1946	.09
20	0	0	41.63	2.4	2 1947	.03
21	0	0	43.75	2.3	2 1949	-.02
22	0	0	45.86	2.2	9 1949	-.07
23	0	0	47.97	2.1	2 1950	-.12
24	0	0	50.09	2.0	3 1952	-.17

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	0	0	1.47	68.1	11 1933	2.83
2	0	0	3.59	27.9	2 1934	2.13
3	0	0	5.70	17.5	10 1935	1.76
4	0	0	7.82	12.8	10 1938	1.51
5	0	0	9.94	10.1	11 1939	1.31
6	0	0	12.06	8.3	2 1940	1.15
7	0	0	14.18	7.1	2 1941	1.01
8	0	0	16.29	6.1	10 1949	.90
9	0	0	18.41	5.4	3 1956	.79
10	0	0	20.53	4.9	10 1956	.70
11	0	0	22.65	4.4	2 1959	.61
12	0	0	24.76	4.0	10 1960	.53
13	0	0	26.88	3.7	1 1961	.46
14	0	0	29.00	3.4	3 1969	.39
15	0	0	31.12	3.2	3 1974	.32
16	60.	.3	33.23	3.0	2 1933	.26
17	60.	.3	35.35	2.8	2 1937	.20
18	60.	.3	37.47	2.7	10 1940	.14
19	60.	.3	39.59	2.5	2 1946	.08
20	60.	.3	41.71	2.4	2 1947	.03
21	60.	.3	43.82	2.3	2 1950	-.02
22	60.	.3	45.94	2.2	3 1952	-.07
23	60.	.3	48.06	2.1	10 1952	-.12
24	60.	.3	50.18	2.0	3 1955	-.17

1

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	0	0	1.47	67.9	12 1933	2.83
2	0	0	3.59	27.8	11 1935	2.13
3	0	0	5.71	17.5	12 1939	1.76
4	0	0	7.84	12.8	11 1960	1.50
5	60.	.3	9.96	10.0	12 1940	1.31
6	60.	.3	12.08	8.3	3 1956	1.15
7	121.	.5	14.20	7.0	10 1938	1.01
8	121.	.5	16.32	6.1	2 1959	.89
9	181.	.8	18.44	5.4	3 1937	.79
10	181.	.8	20.56	4.9	2 1946	.70
11	181.	.8	22.69	4.4	11 1949	.61
12	181.	.8	24.81	4.0	11 1952	.53
13	181.	.8	26.93	3.7	10 1956	.45
14	181.	.8	29.05	3.4	3 1962	.38
15	181.	.8	31.17	3.2	3 1965	.32
16	181.	.8	33.29	3.0	3 1969	.25
17	241.	1.0	35.42	2.8	10 1932	.20
18	241.	1.0	37.54	2.7	3 1955	.14
19	241.	1.0	39.66	2.5	11 1959	.08
20	241.	1.0	41.78	2.4	3 1974	.03
21	302.	1.3	43.90	2.3	2 1933	-.02
22	362.	1.5	46.02	2.2	10 1931	-.07
23	362.	1.5	48.14	2.1	3 1936	-.12
24	362.	1.5	50.27	2.0	2 1939	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	0	0	1.48	67.7	2 1934	2.83
2	0	0	3.61	27.7	2 1940	2.13
3	0	0	5.73	17.4	1 1961	1.76
4	60.	.2	7.86	12.7	2 1941	1.50
5	181.	.5	9.99	10.0	1 1936	1.31
6	241.	.7	12.12	8.2	2 1946	1.15
7	241.	.7	14.25	7.0	1 1950	1.01
8	241.	.7	16.38	6.1	2 1956	.89
9	302.	.8	18.51	5.4	2 1960	.79
10	362.	1.0	20.64	4.8	2 1933	.69
11	362.	1.0	22.77	4.4	1 1939	.61
12	362.	1.0	24.90	4.0	1 1953	.53
13	423.	1.2	27.02	3.7	2 1937	.45
14	483.	1.3	29.15	3.4	3 1955	.38
15	543.	1.5	31.28	3.2	2 1959	.31
16	604.	1.7	33.41	3.0	1 1957	.25
17	664.	1.8	35.54	2.8	2 1938	.19
18	664.	1.8	37.67	2.7	2 1949	.13
19	664.	1.8	39.80	2.5	2 1968	.08
20	724.	2.0	41.93	2.4	2 1931	.03
21	724.	2.0	44.06	2.3	12 1931	-.03
22	724.	2.0	46.19	2.2	2 1935	-.08
23	724.	2.0	48.31	2.1	1 1947	-.13
24	724.	2.0	50.44	2.0	2 1951	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	181.	.3	1.48	67.3	3 1940	2.83
2	241.	.4	3.63	27.6	3 1934	2.12
3	483.	.9	5.77	17.3	2 1961	1.75
4	664.	1.2	7.91	12.6	2 1933	1.50
5	664.	1.2	10.05	10.0	3 1936	1.30
6	845.	1.6	12.19	8.2	3 1937	1.14
7	1147.	2.1	14.33	7.0	2 1950	1.01
8	1207.	2.2	16.47	6.1	3 1957	.89
9	1449.	2.7	18.61	5.4	2 1931	.78
10	1509.	2.8	20.75	4.8	2 1947	.69
11	1630.	3.0	22.89	4.4	2 1939	.60
12	1630.	3.0	25.03	4.0	2 1946	.52
13	1630.	3.0	27.17	3.7	3 1955	.45
14	1811.	3.3	29.31	3.4	3 1941	.38
15	1932.	3.6	31.45	3.2	2 1932	.31
16	1992.	3.7	33.59	3.0	2 1938	.25
17	1992.	3.7	35.73	2.8	3 1962	.19
18	2173.	4.0	37.87	2.6	4 1959	.13
19	2234.	4.1	40.01	2.5	3 1974	.07
20	2475.	4.6	42.15	2.4	3 1964	.02
21	2596.	4.8	44.29	2.3	3 1949	-.03
22	2656.	4.9	46.43	2.2	3 1965	-.08
23	2777.	5.1	48.57	2.1	3 1948	-.13
24	2777.	5.1	50.71	2.0	3 1952	-.18

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   12

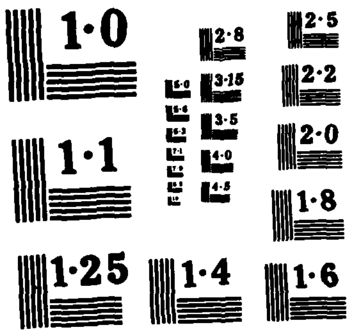
EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2717.	3.8	1.49	67.0	3 1940	2.82
2	3200.	4.4	3.64	27.4	5 1934	2.12
3	4045.	5.6	5.80	17.3	7 1961	1.75
4	4105.	5.7	7.95	12.6	3 1936	1.49
5	4468.	6.2	10.10	9.9	5 1957	1.30
6	4649.	6.4	12.25	8.2	4 1937	1.14
7	5132.	7.1	14.40	6.9	3 1955	1.00
8	5494.	7.6	16.56	6.0	12 1938	.88
9	6158.	8.5	18.71	5.3	5 1959	.78
10	8150.	11.3	20 86	4.8	4 1953	.68
11	8392.	11.6	23.01	4.3	5 1933	.60
12	8996.	12.4	25.16	4.0	3 1974	.52
13	11350.	15.7	27.32	3.7	5 1968	.44
14	11531.	15.9	29.47	3.4	3 1941	.37
15	11773.	16.3	31.62	3.2	8 1944	.30
16	12014.	16.6	33.77	3.0	3 1932	.24
17	12376.	17.1	35.92	2.8	3 1947	.18
18	12618.	17.4	38.07	2.6	4 1956	.12
19	13282.	18.3	40.23	2.5	4 1942	.07
20	13282.	18.3	42.38	2.4	4 1964	.01
21	13946.	19.3	44.53	2.2	12 1945	-.04
22	15214.	21.0	46.68	2.1	12 1949	-.09
23	16361.	22.6	48.83	2.0	5 1958	-.14
24	16603.	22.9	50.99	2.0	3 1931	-.19

1

AD-A157 283 FARGO-MOORHEAD URBAN STUDY WATER SUPPLY APPENDIX VOLUME 4/5
1 PHASE 1 PART 1..(U) CORPS OF ENGINEERS ST PAUL MN ST
PAUL DISTRICT MAY 85

UNCLASSIFIED F/G 13/2 NL



NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	11229.	7.8	1.53	65.5	4 1938	2.81
2	11471.	7.9	3.72	26.8	4 1935	2.10
3	14248.	9.8	5.92	16.9	3 1941	1.73
4	17870.	12.3	8.12	12.3	7 1957	1.47
5	22097.	15.3	10.32	9.7	2 1960	1.28
6	23183.	16.0	12.52	8.0	3 1933	1.12
7	23787.	16.4	14.72	6.8	6 1955	.98
8	26685.	18.4	16.92	5.9	12 1945	.86
9	29221.	20.2	19.12	5.2	3 1962	.76
10	30911.	21.3	21.32	4.7	3 1965	.66
11	44918.	31.0	23.52	4.3	3 1943	.58
12	53128.	36.7	25.72	3.9	1 1950	.50
13	55905.	38.6	27.92	3.6	3 1969	.42
14	59769.	41.3	30.12	3.3	3 1975	.35
15	67316.	46.5	32.31	3.1	4 1953	.28
16	103600.	71.5	34.51	2.9	12 1947	.22
17	115675.	79.8	36.71	2.7	6 1972	.16
18	202672.	139.9	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	26564.	9.2	1.60	62.7	4 1937	2.77
2	39484.	13.6	3.90	25.7	8 1957	2.06
3	40752.	14.1	6.20	16.1	4 1941	1.69
4	53611.	18.5	8.50	11.8	3 1962	1.44
5	63694.	22.0	10.80	9.3	1 1947	1.24
6	179610.	62.0	13.10	7.6	7 1951	1.08
7	191503.	66.1	15.40	6.5	3 1975	.94
8	229659.	79.3	17.70	5.7	12 1966	.83
9	297699.	102.7	20.00	5.0	2 1971	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ.	RECUR INT	ENDING DATE	GUMBEL K
1	60735.	10.5	1.76	56.9	5 1940	2.69
2	95389.	16.5	4.29	23.3	3 1962	1.99
3	234066.	40.4	6.82	14.7	1 1950	1.62
4	494274.	85.3	9.36	10.7	3 1974	1.36

INDEPENDENT EVENTS EXHAUSTED

1

READY.

Red River at Rustad - Year 2030 Case

RED RIVER AT RUSTAD

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	1402.	11.6	1.47	68.2	1 1937	2.84
2	1583.	13.1	3.58	27.9	2 1933	2.13
3	1885.	15.6	5.69	17.6	2 1935	1.76
4	3394.	28.1	7.81	12.8	12 1940	1.51
5	3938.	32.6	9.92	10.1	12 1932	1.31
6	3998.	33.1	12.04	8.3	12 1934	1.15
7	4239.	35.1	14.15	7.1	11 1931	1.02
8	4360.	36.1	16.26	6.1	2 1934	.90
9	4541.	37.6	18.38	5.4	12 1970	.79
10	4602.	38.1	20.49	4.9	12 1939	.70
11	4722.	39.1	22.61	4.4	12 1933	.61
12	4783.	39.6	24.72	4.0	11 1936	.53
13	5085.	42.1	26.83	3.7	11 1935	.46
14	5205.	43.1	28.95	3.5	2 1940	.39
15	5394.	44.7	31.06	3.2	10 1939	.32
16	5394.	44.7	33.18	3.0	10 1933	.26
17	5394.	44.7	35.29	2.8	10 1934	.20
18	5455.	45.2	37.40	2.7	10 1940	.14
19	5455.	45.2	39.52	2.5	10 1932	.09
20	5688.	47.1	41.63	2.4	1 1936	.03
21	5817.	48.2	43.75	2.3	10 1930	-.02
22	5990.	49.6	45.86	2.2	1 1938	-.07
23	6473.	53.6	47.97	2.1	2 1970	-.12
24	6508.	53.9	50.09	2.0	9 1976	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2103.	11.6	1.47	68.1	2 1937	2.83
2	3190.	17.6	3.59	27.9	2 1933	2.13
3	3491.	19.3	5.70	17.5	2 1935	1.76
4	5906.	32.6	7.82	12.8	12 1940	1.51
5	6570.	36.3	9.94	10.1	2 1934	1.31
6	7053.	38.9	12.06	8.3	12 1939	1.15
7	7182.	39.7	14.18	7.1	11 1931	1.01
8	7717.	42.6	16.29	6.1	12 1935	.90
9	7725.	42.7	18.41	5.4	11 1936	.79
10	7786.	43.0	20.53	4.9	11 1934	.70
11	7786.	43.0	22.65	4.4	11 1932	.61
12	7906.	43.7	24.76	4.0	11 1933	.53
13	8442.	46.6	26.88	3.7	1 1971	.46
14	9383.	51.8	29.00	3.4	10 1930	.39
15	9589.	52.9	31.12	3.2	2 1938	.32
16	11393.	62.9	33.23	3.0	8 1932	.26
17	11816.	65.2	35.35	2.8	8 1934	.20
18	11944.	65.9	37.47	2.7	1 1970	.14
19	12341.	68.1	39.59	2.5	10 1938	.08
20	12487.	68.9	41.71	2.4	2 1931	.03
21	12859.	71.0	43.82	2.3	9 1940	-.02
22	13151.	72.6	45.94	2.2	2 1932	-.07
23	13325.	73.6	48.06	2.1	8 1936	-.12
24	13393.	73.9	50.18	2.0	1 1939	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4494.	18.6	1.47	67.9	2 1937	2.83
2	5521.	22.9	3.59	27.8	2 1933	2.13
3	5883.	24.4	5.71	17.5	2 1935	1.76
4	8849.	36.6	7.84	12.8	12 1940	1.50
5	9083.	37.6	9.96	10.0	2 1934	1.31
6	9686.	40.1	12.08	8.3	1 1940	1.15
7	10539.	43.6	14.20	7.0	12 1931	1.01
8	10600.	43.9	16.32	6.1	12 1935	.89
9	12896.	53.4	18.44	5.4	10 1936	.79
10	12956.	53.6	20.56	4.9	10 1934	.70
11	12956.	53.6	22.69	4.4	10 1933	.61
12	13016.	53.9	24.81	4.0	10 1932	.53
13	14705.	60.9	26.93	3.7	12 1930	.45
14	15542.	64.4	29.05	3.4	2 1938	.38
15	15844.	65.6	31.17	3.2	2 1970	.32
16	16154.	66.9	33.29	3.0	12 1938	.25
17	16810.	69.6	35.42	2.8	2 1971	.20
18	21580.	89.4	37.54	2.7	1 1930	.14
19	22916.	94.9	39.66	2.5	12 1961	.08
20	26613.	110.2	41.78	2.4	6 1934	.03
21	27194.	112.6	43.90	2.3	4 1931	-.02
22	27315.	113.1	46.02	2.2	1 1975	-.07
23	27557.	114.1	48.14	2.1	4 1932	-.12
24	28014.	116.0	50.27	2.0	11 1941	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	9828.	27.1	1.48	67.7	2 1937	2.83
2	10975.	30.3	3.61	27.7	2 1933	2.13
3	11277.	31.1	5.73	17.4	2 1935	1.76
4	14477.	40.0	7.86	12.7	2 1934	1.50
5	15201.	42.0	9.99	10.0	2 1940	1.31
6	16677.	46.0	12.12	8.2	1 1941	1.15
7	17013.	47.0	14.25	7.0	2 1936	1.01
8	18308.	50.5	16.38	6.1	1 1932	.89
9	22292.	61.5	18.51	5.4	1 1931	.79
10	25733.	71.0	20.64	4.8	1 1939	.69
11	29691.	82.0	22.77	4.4	2 1970	.61
12	31804.	87.8	24.90	4.0	2 1938	.53
13	34175.	94.3	27.02	3.7	8 1934	.45
14	35936.	99.2	29.15	3.4	1 1962	.38
15	37616.	103.8	31.28	3.2	8 1932	.31
16	43818.	121.0	33.41	3.0	2 1971	.25
17	44724.	123.5	35.54	2.8	2 1957	.19
18	45596.	125.9	37.67	2.7	1 1942	.13
19	48165.	133.0	39.80	2.5	2 1949	.08
20	51485.	142.1	41.93	2.4	2 1950	.03
21	53856.	148.7	44.06	2.3	8 1933	-.03
22	60481.	167.0	46.19	2.2	2 1968	-.08
23	61074.	168.6	48.31	2.1	7 1931	-.13
24	62232.	171.8	50.44	2.0	2 1961	-.17

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	22368.	41.2	1.48	67.3	2 1933	2.83
2	23093.	42.5	3.63	27.6	2 1935	2.12
3	23153.	42.6	5.77	17.3	2 1937	1.75
4	28405.	52.3	7.91	12.6	2 1934	1.50
5	36927.	68.0	10.05	10.0	3 1940	1.30
6	41662.	76.7	12.19	8.2	4 1932	1.14
7	43870.	80.7	14.33	7.0	3 1941	1.01
8	44344.	81.6	16.47	6.1	2 1936	.89
9	45465.	83.7	18.61	5.4	4 1931	.78
10	58747.	108.1	20.75	4.8	4 1938	.69
11	68614.	126.3	22.89	4.4	2 1939	.60
12	71702.	132.0	25.03	4.0	3 1962	.52
13	82328.	151.5	27.17	3.7	3 1942	.45
14	88390.	162.7	29.31	3.4	4 1970	.38
15	94523.	174.0	31.45	3.2	3 1949	.31
16	96480.	177.6	33.59	3.0	4 1961	.25
17	102734.	189.1	35.73	2.8	3 1957	.19
18	109284.	201.1	37.87	2.6	5 1971	.13
19	110668.	203.7	40.01	2.5	4 1968	.07
20	116137.	213.7	42.15	2.4	3 1965	.02
21	119543.	220.0	44.29	2.3	4 1959	-.03
22	124770.	229.6	46.43	2.2	3 1964	-.08
23	131134.	241.3	48.57	2.1	4 1955	-.13
24	140880.	259.3	50.71	2.0	2 1950	-.18

(continued)

YEARS (RECORD) MONTHS 47 0

DURATION IN MONTHS 12

EFFECTIVE YEARS 46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	45452.	62.7	1.49	67.0	2 1935	2.82
2	46478.	64.2	3.64	27.4	3 1933	2.12
3	51791.	71.5	5.80	17.3	5 1937	1.75
4	79200.	109.3	7.95	12.6	12 1931	1.49
5	84332.	116.4	10.10	9.9	12 1940	1.30
6	87230.	120.4	12.25	8.2	3 1936	1.14
7	100874.	139.2	14.40	6.9	11 1938	1.00
8	120375.	166.2	16.56	6.0	12 1939	.88
9	123393.	170.3	18.71	5.3	3 1962	.78
10	146697.	202.5	20.86	4.8	12 1941	.68
11	149414.	206.2	23.01	4.3	12 1930	.60
12	159979.	220.8	25.16	4.0	6 1949	.52
13	169881.	234.5	27.32	3.7	4 1959	.44
14	195298.	269.6	29.47	3.4	6 1971	.37
15	202723.	279.8	31.62	3.2	9 1976	.30
16	204233.	281.9	33.77	3.0	7 1955	.24
17	206406.	284.9	35.92	2.8	8 1968	.18
18	213108.	294.2	38.07	2.6	6 1970	.12
19	220654.	304.6	40.23	2.5	4 1957	.07
20	230857.	318.7	42.38	2.4	10 1964	.01
21	249452.	344.3	44.53	2.2	4 1960	-.04
22	265511.	366.5	46.68	2.1	9 1973	-.09
23	287185.	396.4	48.83	2.0	6 1946	-.14
24	317794.	438.7	50.99	2.0	10 1963	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	111672.	77.1	1.53	65.5	4 1934	2.81
2	148681.	102.6	3.72	26.8	5 1937	2.10
3	188648.	130.2	5.92	16.9	4 1932	1.73
4	194323.	134.1	8.12	12.3	3 1941	1.47
5	379185.	261.7	10.32	9.7	3 1962	1.28
6	402368.	277.7	12.52	8.0	3 1960	1.12
7	408405.	281.9	14.72	6.8	6 1971	.98
8	475117.	327.9	16.92	5.9	1 1950	.86
9	476446.	328.8	19.12	5.2	2 1957	.76
10	514239.	354.9	21.32	4.7	3 1965	.66
11	549980.	379.6	23.52	4.3	3 1943	.58
12	616692.	425.6	25.72	3.9	9 1976	.50
13	619107.	427.3	27.92	3.6	3 1969	.42
14	698135.	481.8	30.12	3.3	9 1974	.35
15	743958.	513.4	32.31	3.1	3 1947	.28
16	798354.	551.0	34.51	2.9	2 1955	.22
17	977059.	674.3	36.71	2.7	1 1952	.16
18	1155642.	797.6	38.91	2.6	3 1945	.10
19	1316174.	908.4	41.11	2.4	3 1967	.05

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	242361.	83.6	1.60	62.7	2 1935	2.77
2	368360.	127.1	3.90	25.7	2 1939	2.06
3	739775.	255.3	6.20	16.1	2 1943	1.69
4	781553.	269.7	8.50	11.8	3 1962	1.44
5	1162869.	401.3	10.80	9.3	3 1958	1.24
6	1278966.	441.3	13.10	7.6	7 1971	1.08
7	1314827.	453.7	15.40	6.5	9 1976	.94
8	1374597.	474.3	17.70	5.7	7 1951	.83
9	1778613.	613.8	20.00	5.0	10 1966	.72
10	1869051.	645.0	22.30	4.5	6 1947	.62

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	596534.	102.9	1.76	56.9	6 1938	2.69
2	1944421.	335.5	4.29	23.3	3 1962	1.99
3	2418530.	417.3	6.82	14.7	6 1946	1.62
4	2979456.	514.1	9.36	10.7	6 1975	1.36

INDEPENDENT EVENTS EXHAUSTED

Red River at Briarwood - Year 2030 Case

RED RIVER AT BRIARWOOD / FRONTIER

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	1032.	8.5	1.47	68.2	2 1933	2.84
2	1153.	9.5	3.58	27.9	2 1937	2.13
3	1334.	11.0	5.69	17.6	2 1935	1.76
4	3025.	25.0	7.81	12.8	12 1936	1.51
5	3930.	32.5	9.92	10.1	12 1934	1.31
6	3930.	32.5	12.04	8.3	12 1932	1.15
7	4534.	37.5	14.15	7.1	12 1970	1.02
8	4534.	37.5	16.26	6.1	12 1933	.90
9	4534.	37.5	18.38	5.4	12 1939	.79
10	4715.	39.1	20.49	4.9	12 1940	.70
11	4836.	40.0	22.61	4.4	2 1940	.61
12	4896.	40.5	24.72	4.0	2 1934	.53
13	4944.	40.9	26.83	3.7	11 1935	.46
14	5306.	43.9	28.95	3.5	11 1931	.39
15	5435.	45.0	31.06	3.2	10 1933	.32
16	5435.	45.0	33.18	3.0	10 1934	.26
17	5435.	45.0	35.29	2.8	10 1936	.20
18	5435.	45.0	37.40	2.7	10 1932	.14
19	5435.	45.0	39.52	2.5	10 1939	.09
20	5435.	45.0	41.63	2.4	10 1940	.03
21	5741.	47.5	43.75	2.3	1 1938	-.02
22	5857.	48.5	45.86	2.2	10 1930	-.07
23	5862.	48.5	47.97	2.1	1 1936	-.12
24	6501.	53.8	50.09	2.0	9 1976	-.17

(continued)

YEARS (RECORD) MONTHS 47 0 DURATION IN MONTHS 3

EFFECTIVE YEARS 46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	1850.	10.2	1.47	68.1	2 1937	2.83
2	2635.	14.5	3.59	27.9	2 1933	2.13
3	2937.	16.2	5.70	17.5	2 1935	1.76
4	6922.	38.2	7.82	12.8	1 1940	1.51
5	6922.	38.2	9.94	10.1	1 1934	1.31
6	7211.	39.8	12.06	8.3	12 1940	1.15
7	7573.	41.8	14.18	7.1	12 1935	1.01
8	7762.	42.9	16.29	6.1	11 1936	.90
9	7762.	42.9	18.41	5.4	11 1932	.79
10	7762.	42.9	20.53	4.9	11 1934	.70
11	8245.	45.5	22.65	4.4	11 1931	.61
12	8431.	46.5	24.76	4.0	1 1971	.53
13	8997.	49.7	26.88	3.7	10 1939	.46
14	8997.	49.7	29.00	3.4	10 1933	.39
15	9337.	51.5	31.12	3.2	2 1938	.32
16	9419.	52.0	33.23	3.0	10 1930	.26
17	11551.	63.8	35.35	2.8	8 1932	.20
18	11913.	65.8	37.47	2.7	8 1934	.14
19	12114.	66.9	39.59	2.5	1 1970	.08
20	12351.	68.2	41.71	2.4	11 1938	.03
21	12476.	68.9	43.82	2.3	2 1931	-.02
22	12848.	70.9	45.94	2.2	9 1940	-.07
23	13362.	73.8	48.06	2.1	8 1936	-.12
24	13623.	75.2	50.18	2.0	2 1932	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4178.	17.3	1.47	67.9	2 1937	2.83
2	4963.	20.5	3.59	27.8	2 1933	2.13
3	5265.	21.8	5.71	17.5	2 1935	1.76
4	9370.	38.8	7.84	12.8	2 1940	1.50
5	9418.	39.0	9.96	10.0	1 1934	1.31
6	10150.	42.0	12.08	8.3	12 1940	1.15
7	10512.	43.5	14.20	7.0	12 1935	1.01
8	11807.	48.9	16.32	6.1	11 1931	.89
9	12989.	53.8	18.44	5.4	10 1932	.79
10	12989.	53.8	20.56	4.9	10 1936	.70
11	12989.	53.8	22.69	4.4	10 1934	.61
12	14645.	60.6	24.81	4.0	11 1930	.53
13	15347.	63.5	26.93	3.7	2 1938	.45
14	16066.	66.5	29.05	3.4	12 1938	.38
15	16071.	66.5	31.17	3.2	2 1970	.32
16	16796.	69.5	33.29	3.0	2 1971	.25
17	16965.	70.2	35.42	2.8	9 1933	.20
18	19389.	80.3	37.54	2.7	10 1939	.14
19	22639.	93.7	39.66	2.5	1 1930	.08
20	23311.	96.5	41.78	2.4	12 1961	.03
21	23468.	97.2	43.90	2.3	5 1934	-.02
22	26926.	111.5	46.02	2.2	1 1975	-.07
23	27663.	114.5	48.14	2.1	3 1931	-.12
24	28750.	119.0	50.27	2.0	3 1932	-.17

(continued)

YEARS (RECORD) MONTHS 47 0

DURATION IN MONTHS 6

EFFECTIVE YEARS 46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	9613.	26.5	1.48	67.7	2 1937	2.83
2	10397.	28.7	3.61	27.7	2 1933	2.13
3	10699.	29.5	5.73	17.4	2 1935	1.76
4	14805.	40.9	7.86	12.7	2 1940	1.50
5	14865.	41.0	9.99	10.0	2 1934	1.31
6	17038.	47.0	12.12	8.2	2 1936	1.15
7	18696.	51.6	14.25	7.0	1 1941	1.01
8	20024.	55.3	16.38	6.1	1 1932	.89
9	22137.	61.1	18.51	5.4	1 1931	.79
10	28054.	77.4	20.64	4.8	1 1939	.69
11	30139.	83.2	22.77	4.4	2 1970	.61
12	32132.	88.7	24.90	4.0	2 1938	.53
13	32872.	90.7	27.02	3.7	8 1934	.45
14	36506.	100.8	29.15	3.4	1 1962	.38
15	40721.	112.4	31.28	3.2	8 1932	.31
16	43844.	121.0	33.41	3.0	2 1971	.25
17	45293.	125.0	35.54	2.8	2 1957	.19
18	48158.	132.9	37.67	2.7	1 1942	.13
19	50787.	140.2	39.80	2.5	2 1949	.08
20	52977.	146.2	41.93	2.4	8 1933	.03
21	53383.	147.4	44.06	2.3	2 1950	-.03
22	61533.	169.9	46.19	2.2	2 1961	-.08
23	61594.	170.0	48.31	2.1	2 1968	-.13
24	62854.	173.5	50.44	2.0	3 1975	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	21948.	40.4	1.48	67.3	2 1933	2.83
2	22612.	41.6	3.63	27.6	2 1935	2.12
3	22974.	42.3	5.77	17.3	2 1937	1.75
4	28891.	53.2	7.91	12.6	2 1934	1.50
5	37304.	68.7	10.05	10.0	3 1940	1.30
6	45394.	83.5	12.19	8.2	3 1932	1.14
7	46942.	86.4	14.33	7.0	2 1936	1.01
8	49163.	90.5	16.47	6.1	4 1931	.89
9	53644.	98.7	18.61	5.4	2 1941	.78
10	65162.	119.9	20.75	4.8	4 1938	.69
11	70691.	130.1	22.89	4.4	3 1962	.60
12	72601.	133.6	25.03	4.0	2 1939	.52
13	84516.	155.5	27.17	3.7	3 1942	.45
14	96832.	178.2	29.31	3.4	3 1949	.38
15	107906.	198.6	31.45	3.2	4 1961	.31
16	109390.	201.3	33.59	3.0	3 1970	.25
17	109994.	202.4	35.73	2.8	3 1957	.19
18	126415.	232.7	37.87	2.6	3 1965	.13
19	127467.	234.6	40.01	2.5	4 1959	.07
20	129399.	238.1	42.15	2.4	4 1968	.02
21	130550.	240.3	44.29	2.3	5 1971	-.03
22	135894.	250.1	46.43	2.2	3 1964	-.08
23	153764.	283.0	48.57	2.1	3 1960	-.13
24	154044.	283.5	50.71	2.0	2 1950	-.18

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	43572.	60.1	1.49	67.0	2 1935	2.82
2	45323.	62.6	3.64	27.4	3 1933	2.12
3	67298.	92.9	5.80	17.3	3 1937	1.75
4	84927.	117.2	7.95	12.6	12 1931	1.49
5	94949.	131.1	10.10	9.9	3 1936	1.30
6	95311.	131.6	12.25	8.2	7 1940	1.14
7	112940.	155.9	14.40	6.9	11 1938	1.00
8	129422.	178.6	16.56	6.0	3 1962	.88
9	149889.	206.9	18.71	5.3	7 1941	.78
10	162144.	223.8	20.86	4.8	12 1930	.68
11	181403.	250.4	23.01	4.3	6 1949	.60
12	214186.	295.6	25.16	4.0	6 1971	.52
13	219136.	302.5	27.32	3.7	5 1959	.44
14	236947.	327.1	29.47	3.4	8 1968	.37
15	241535.	333.4	31.62	3.2	9 1976	.30
16	251859.	347.6	33.77	3.0	7 1955	.24
17	258741.	357.1	35.92	2.8	4 1957	.18
18	284098.	392.1	38.07	2.6	9 1973	.12
19	296474.	409.2	40.23	2.5	6 1970	.07
20	300700.	415.1	42.38	2.4	10 1964	.01
21	321046.	443.1	44.53	2.2	2 1961	-.04
22	346524.	478.3	46.68	2.1	7 1942	-.09
23	367111.	506.7	48.83	2.0	6 1946	-.14
24	390354.	538.8	50.99	2.0	3 1975	-.19

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	109602.	75.6	1.53	65.5	4 1934	2.81
2	162248.	112.0	3.72	26.8	3 1937	2.10
3	200886.	138.6	5.92	16.9	4 1932	1.73
4	229201.	158.2	8.12	12.3	5 1941	1.47
5	290902.	200.8	10.32	9.7	3 1939	1.28
6	455057.	314.1	12.52	8.0	3 1962	1.12
7	488201.	336.9	14.72	6.8	3 1960	.98
8	510660.	352.4	16.92	5.9	6 1971	.86
9	562581.	388.3	19.12	5.2	1 1950	.76
10	580572.	400.7	21.32	4.7	2 1957	.66
11	685017.	472.8	23.52	4.3	3 1965	.58
12	692262.	477.8	25.72	3.9	3 1975	.50
13	854001.	589.4	27.92	3.6	3 1969	.42
14	909545.	627.7	30.12	3.3	3 1947	.35
15	1054742.	727.9	32.31	3.1	2 1955	.28
16	1190521.	821.6	34.51	2.9	5 1943	.22
17	1379488.	952.1	36.71	2.7	1 1952	.16
18	1887285.	1302.5	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED
1

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	248848.	85.9	1.60	62.7	2 1935	2.77
2	429182.	148.1	3.90	25.7	2 1939	2.06
3	926897.	319.9	6.20	16.1	3 1943	1.69
4	943258.	325.5	8.50	11.8	3 1962	1.44
5	1402817.	484.1	10.80	9.3	3 1958	1.24
6	1651494.	569.9	13.10	7.6	3 1950	1.08
7	1659101.	572.5	15.40	6.5	8 1973	.94
8	2496837.	861.6	17.70	5.7	10 1966	.83
9	3115237.	1075.0	20.00	5.0	3 1954	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	660280.	113.9	1.76	56.9	6 1938	2.69
2	2346075.	404.8	4.29	23.3	3 1962	1.99
3	3584929.	618.5	6.82	14.7	6 1946	1.62
4	4191557.	723.2	9.36	10.7	3 1975	1.36

INDEPENDENT EVENTS EXHAUSTED

1

Red River at Fargo - Year 2030 Case

RED RIVER AT FARGO / MOORHEAD / PRAIRIE ROSE / DILWORTH

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4046.	33.5	1.47	68.2	2 1933	2.84
2	4167.	34.5	3.58	27.9	2 1937	2.13
3	4348.	36.0	5.69	17.6	2 1935	1.76
4	4536.	37.6	7.81	12.8	12 1970	1.51
5	4536.	37.6	9.92	10.1	12 1939	1.31
6	4536.	37.6	12.04	8.3	12 1936	1.15
7	4536.	37.6	14.15	7.1	12 1933	1.02
8	4717.	39.1	16.26	6.1	12 1940	.90
9	4825.	40.0	18.38	5.4	11 1932	.79
10	4825.	40.0	20.49	4.9	11 1934	.70
11	4831.	40.0	22.61	4.4	2 1940	.61
12	4891.	40.5	24.72	4.0	2 1934	.53
13	4946.	41.0	26.83	3.7	11 1935	.46
14	5308.	44.0	28.95	3.5	11 1931	.39
15	5371.	44.5	31.06	3.2	10 1940	.32
16	5371.	44.5	33.18	3.0	10 1939	.26
17	5371.	44.5	35.29	2.8	10 1936	.20
18	5371.	44.5	37.40	2.7	10 1933	.14
19	5737.	47.5	39.52	2.5	1 1938	.09
20	5794.	48.0	41.63	2.4	10 1930	.03
21	5857.	48.5	43.75	2.3	1 1936	-.02
22	6348.	52.6	45.86	2.2	9 1976	-.07
23	6348.	52.6	47.97	2.1	9 1932	-.12
24	6348.	52.6	50.09	2.0	9 1931	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	6371.	35.2	1.47	68.1	2 1937	2.83
2	6921.	38.2	3.59	27.9	1 1940	2.13
3	6921.	38.2	5.70	17.5	1 1934	1.76
4	7156.	39.5	7.82	12.8	2 1933	1.51
5	7210.	39.8	9.94	10.1	12 1940	1.31
6	7344.	40.5	12.06	8.3	1 1935	1.15
7	7573.	41.8	14.18	7.1	12 1935	1.01
8	7703.	42.5	16.29	6.1	11 1936	.90
9	7703.	42.5	18.41	5.4	11 1932	.79
10	8186.	45.2	20.53	4.9	11 1931	.70
11	8430.	46.5	22.65	4.4	1 1971	.61
12	8842.	48.8	24.76	4.0	10 1939	.53
13	8842.	48.8	26.88	3.7	10 1934	.46
14	8842.	48.8	29.00	3.4	10 1933	.39
15	9264.	51.1	31.12	3.2	10 1930	.32
16	9329.	51.5	33.23	3.0	2 1938	.26
17	11304.	62.4	35.35	2.8	8 1932	.20
18	12113.	66.9	37.47	2.7	1 1970	.14
19	12223.	67.5	39.59	2.5	10 1938	.08
20	12469.	68.8	41.71	2.4	2 1931	.03
21	12571.	69.4	43.82	2.3	9 1940	-.02
22	13115.	72.4	45.94	2.2	8 1936	-.07
23	13616.	75.2	48.06	2.1	2 1932	-.12
24	13623.	75.2	50.18	2.0	4 1934	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	8703.	36.0	1.47	67.9	2 1937	2.83
2	9367.	38.8	3.59	27.8	2 1940	2.13
3	9415.	39.0	5.71	17.5	1 1934	1.76
4	9488.	39.3	7.84	12.8	2 1933	1.50
5	9789.	40.5	9.96	10.0	2 1935	1.31
6	10088.	41.8	12.08	8.3	12 1940	1.15
7	10451.	43.3	14.20	7.0	12 1935	1.01
8	11656.	48.3	16.32	6.1	11 1931	.89
9	12710.	52.6	18.44	5.4	10 1936	.79
10	12710.	52.6	20.56	4.9	10 1934	.70
11	12710.	52.6	22.69	4.4	10 1932	.61
12	14494.	60.0	24.81	4.0	11 1930	.53
13	15344.	63.5	26.93	3.7	2 1938	.45
14	16005.	66.3	29.05	3.4	12 1938	.38
15	16068.	66.5	31.17	3.2	2 1970	.32
16	16658.	69.0	33.29	3.0	9 1933	.25
17	16793.	69.5	35.42	2.8	2 1971	.20
18	19109.	79.1	37.54	2.7	10 1939	.14
19	22636.	93.7	39.66	2.5	1 1930	.08
20	23250.	96.3	41.78	2.4	12 1961	.03
21	23453.	97.1	43.90	2.3	5 1934	-.02
22	26923.	111.5	46.02	2.2	1 1975	-.07
23	27653.	114.5	48.14	2.1	3 1931	-.12
24	28740.	119.0	50.27	2.0	3 1932	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS

47   0   6

EFFECTIVE YEARS

46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	14074.	38.9	1.48	67.7	2 1937	2.83
2	14738.	40.7	3.61	27.7	2 1940	2.13
3	14799.	40.9	5.73	17.4	2 1934	1.76
4	14859.	41.0	7.86	12.7	2 1933	1.50
5	15161.	41.9	9.99	10.0	2 1935	1.31
6	16972.	46.9	12.12	8.2	2 1936	1.15
7	18540.	51.2	14.25	7.0	1 1941	1.01
8	19868.	54.8	16.38	6.1	1 1932	.89
9	21981.	60.7	18.51	5.4	1 1931	.79
10	27898.	77.0	20.64	4.8	1 1939	.69
11	30073.	83.0	22.77	4.4	2 1970	.61
12	32065.	88.5	24.90	4.0	2 1938	.53
13	32613.	90.0	27.02	3.7	8 1934	.45
14	36350.	100.3	29.15	3.4	1 1962	.38
15	40462.	111.7	31.28	3.2	8 1932	.31
16	43778.	120.9	33.41	3.0	2 1971	.25
17	45227.	124.9	35.54	2.8	2 1957	.19
18	48002.	132.5	37.67	2.7	1 1942	.13
19	50721.	140.0	39.80	2.5	2 1949	.08
20	52718.	145.5	41.93	2.4	8 1933	.03
21	53317.	147.2	44.06	2.3	2 1950	-.03
22	61467.	169.7	46.19	2.2	2 1961	-.08
23	61527.	169.9	48.31	2.1	2 1968	-.13
24	62846.	173.5	50.44	2.0	3 1975	-.17

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	26163.	48.2	1.48	67.3	2 1933	2.83
2	26827.	49.4	3.63	27.6	2 1935	2.12
3	27190.	50.0	5.77	17.3	2 1937	1.75
4	28578.	52.6	7.91	12.6	2 1934	1.50
5	37020.	68.1	10.05	10.0	3 1940	1.30
6	45109.	83.0	12.19	8.2	3 1932	1.14
7	46630.	85.8	14.33	7.0	2 1936	1.01
8	49007.	90.2	16.47	6.1	4 1931	.89
9	53331.	98.2	18.61	5.4	2 1941	.78
10	65005.	119.6	20.75	4.8	4 1938	.69
11	70406.	129.6	22.89	4.4	3 1962	.60
12	72288.	133.0	25.03	4.0	2 1939	.52
13	84231.	155.0	27.17	3.7	3 1942	.45
14	96547.	177.7	29.31	3.4	3 1949	.38
15	107750.	198.3	31.45	3.2	4 1961	.31
16	109105.	200.8	33.59	3.0	3 1970	.25
17	109709.	201.9	35.73	2.8	3 1957	.19
18	126130.	232.1	37.87	2.6	3 1965	.13
19	127310.	234.3	40.01	2.5	4 1959	.07
20	129242.	237.9	42.15	2.4	4 1968	.02
21	130471.	240.1	44.29	2.3	5 1971	-.03
22	135609.	249.6	46.43	2.2	3 1964	-.08
23	153479.	282.5	48.57	2.1	3 1960	-.13
24	153731.	282.9	50.71	2.0	2 1950	-.18

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	47412.	65.4	1.49	67.0	6 1934	2.82
2	49525.	68.4	3.64	27.4	3 1933	2.12
3	71501.	98.7	5.80	17.3	3 1937	1.75
4	84602.	116.8	7.95	12.6	12 1931	1.49
5	94624.	130.6	10.10	9.9	3 1936	1.30
6	94986.	131.1	12.25	8.2	7 1940	1.14
7	112615.	155.4	14.40	6.9	11 1938	1.00
8	129097.	178.2	16.56	6.0	3 1962	.88
9	149563.	206.4	18.71	5.3	7 1941	.78
10	161819.	223.4	20.86	4.8	12 1930	.68
11	181078.	249.9	23.01	4.3	6 1949	.60
12	213860.	295.2	25.16	4.0	6 1971	.52
13	218811.	302.0	27.32	3.7	5 1959	.44
14	236621.	326.6	29.47	3.4	8 1968	.37
15	241209.	332.9	31.62	3.2	9 1976	.30
16	251533.	347.2	33.77	3.0	7 1955	.24
17	258416.	356.7	35.92	2.8	4 1957	.18
18	283772.	391.7	38.07	2.6	9 1973	.12
19	296149.	408.8	40.23	2.5	6 1970	.07
20	300375.	414.6	42.38	2.4	10 1964	.01
21	320721.	442.7	44.53	2.2	2 1961	-.04
22	346198.	477.9	46.68	2.1	7 1942	-.09
23	366785.	506.3	48.83	2.0	6 1946	-.14
24	390029.	538.4	50.99	2.0	3 1975	-.19

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	113480.	78.3	1.53	65.5	4 1934	2.81
2	166125.	114.7	3.72	26.8	3 1937	2.10
3	200236.	138.2	5.92	16.9	4 1932	1.73
4	228550.	157.7	8.12	12.3	5 1941	1.47
5	290252.	200.3	10.32	9.7	3 1939	1.28
6	454406.	313.6	12.52	8.0	3 1962	1.12
7	487551.	336.5	14.72	6.8	3 1960	.98
8	510009.	352.0	16.92	5.9	6 1971	.86
9	561930.	387.8	19.12	5.2	1 1950	.76
10	579921.	400.2	21.32	4.7	2 1957	.66
11	684367.	472.3	23.52	4.3	3 1965	.58
12	691611.	477.3	25.72	3.9	3 1975	.50
13	853351.	588.9	27.92	3.6	3 1969	.42
14	908894.	627.3	30.12	3.3	3 1947	.35
15	1054091.	727.5	32.31	3.1	2 1955	.28
16	1189870.	821.2	34.51	2.9	5 1943	.22
17	1378837.	951.6	36.71	2.7	1 1952	.16
18	1886635.	1302.1	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

1

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	256602.	88.5	1.60	62.7	2 1935	2.77
2	432408.	149.2	3.90	25.7	2 1939	2.06
3	925595.	319.4	6.20	16.1	3 1943	1.69
4	941956.	325.0	8.50	11.8	3 1962	1.44
5	1401516.	483.6	10.80	9.3	3 1958	1.24
6	1650192.	569.4	13.10	7.6	3 1950	1.08
7	1657799.	572.1	15.40	6.5	8 1973	.94
8	2495535.	861.2	17.70	5.7	10 1966	.83
9	3113935.	1074.5	20.00	5.0	3 1954	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	671261.	115.8	1.76	56.9	6 1938	2.69
2	2343472.	404.3	4.29	23.3	3 1962	1.99
3	3582326.	618.1	6.82	14.7	6 1946	1.62
4	4188954.	722.8	9.36	10.7	3 1975	1.36

INDEPENDENT EVENTS EXHAUSTED

1

Red River at North River - Year 2030 Case

RED RIVER AT NORTH RIVER / KRAGNES

YEARS (RECORD) MONTHS DURATION IN MONTHS

47 0 2

EFFECTIVE YEARS

46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	1136.	9.4	1.47	68.2	2 1933	2.84
2	1256.	10.4	3.58	27.9	2 1937	2.13
3	1347.	11.2	5.69	17.6	2 1935	1.76
4	1830.	15.2	7.81	12.8	2 1940	1.51
5	1890.	15.7	9.92	10.1	2 1934	1.31
6	2009.	16.6	12.04	8.3	12 1970	1.15
7	2009.	16.6	14.15	7.1	12 1939	1.02
8	2009.	16.6	16.26	6.1	12 1936	.90
9	2009.	16.6	18.38	5.4	12 1933	.79
10	2167.	17.9	20.49	4.9	11 1934	.70
11	2167.	17.9	22.61	4.4	11 1932	.61
12	2190.	18.1	24.72	4.0	12 1940	.53
13	2288.	18.9	26.83	3.7	11 1935	.46
14	2483.	20.6	28.95	3.5	10 1939	.39
15	2483.	20.6	31.06	3.2	10 1940	.32
16	2483.	20.6	33.18	3.0	10 1936	.26
17	2483.	20.6	35.29	2.8	10 1933	.20
18	2544.	21.1	37.40	2.7	10 1931	.14
19	2906.	24.1	39.52	2.5	10 1930	.09
20	3102.	25.7	41.63	2.4	9 1976	.03
21	3102.	25.7	43.75	2.3	9 1934	-.02
22	3102.	25.7	45.86	2.2	9 1932	-.07
23	3177.	26.3	47.97	2.1	1 1938	-.12
24	3298.	27.3	50.09	2.0	1 1936	-.17

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2216.	12.2	1.47	68.1	2 1937	2.83
2	2790.	15.4	3.59	27.9	2 1940	2.13
3	2850.	15.7	5.70	17.5	2 1934	1.76
4	3001.	16.6	7.82	12.8	2 1933	1.51
5	3212.	17.7	9.94	10.1	2 1935	1.31
6	3308.	18.3	12.06	8.3	12 1940	1.15
7	3532.	19.5	14.18	7.1	11 1939	1.01
8	3532.	19.5	16.29	6.1	11 1934	.90
9	3532.	19.5	18.41	5.4	11 1933	.79
10	3532.	19.5	20.53	4.9	11 1936	.70
11	3532.	19.5	22.65	4.4	11 1932	.61
12	3653.	20.2	24.76	4.0	11 1935	.53
13	4015.	22.2	26.88	3.7	11 1931	.46
14	4588.	25.3	29.00	3.4	1 1971	.39
15	4643.	25.6	31.12	3.2	10 1930	.32
16	4903.	27.1	33.23	3.0	2 1936	.26
17	5084.	28.1	35.35	2.8	2 1938	.20
18	5792.	32.0	37.47	2.7	8 1932	.14
19	6154.	34.0	39.59	2.5	8 1934	.08
20	7174.	39.6	41.71	2.4	9 1940	.03
21	7602.	42.0	43.82	2.3	10 1938	-.02
22	7603.	42.0	45.94	2.2	8 1936	-.07
23	8223.	45.4	48.06	2.1	2 1931	-.12
24	8267.	45.6	50.18	2.0	8 1933	-.17

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	3265.	13.5	1.47	67.9	2 1937	2.83
2	3839.	15.9	3.59	27.8	2 1940	2.13
3	3899.	16.1	5.71	17.5	2 1934	1.76
4	4050.	16.8	7.84	12.8	2 1933	1.50
5	4261.	17.6	9.96	10.0	2 1935	1.31
6	4673.	19.3	12.08	8.3	12 1940	1.15
7	5035.	20.8	14.20	7.0	12 1935	1.01
8	5752.	23.8	16.32	6.1	11 1931	.89
9	5938.	24.6	18.44	5.4	10 1936	.79
10	5938.	24.6	20.56	4.9	10 1932	.70
11	5938.	24.6	22.69	4.4	10 1934	.61
12	5938.	24.6	24.81	4.0	10 1933	.53
13	8590.	35.6	26.93	3.7	11 1930	.45
14	9815.	40.6	29.05	3.4	2 1938	.38
15	10160.	42.1	31.17	3.2	11 1938	.32
16	10540.	43.6	33.29	3.0	2 1970	.25
17	11264.	46.6	35.42	2.8	2 1971	.20
18	12338.	51.1	37.54	2.7	10 1939	.14
19	17419.	72.1	39.66	2.5	1 1930	.08
20	17834.	73.8	41.78	2.4	12 1961	.03
21	19182.	79.4	43.90	2.3	6 1934	-.02
22	21706.	89.9	46.02	2.2	1 1975	-.07
23	22010.	91.1	48.14	2.1	3 1931	-.12
24	23097.	95.6	50.27	2.0	3 1932	-.17

(continued)

YEARS (RECORD) MONTHS 47 0

DURATION IN MONTHS 6

EFFECTIVE YEARS 46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	5748.	15.9	1.48	67.7	2 1937	2.83
2	6322.	17.5	3.61	27.7	2 1940	2.13
3	6382.	17.6	5.73	17.4	2 1934	1.76
4	6533.	18.0	7.86	12.7	2 1933	1.50
5	6744.	18.6	9.99	10.0	2 1935	1.31
6	8555.	23.6	12.12	8.2	2 1936	1.15
7	10077.	27.8	14.25	7.0	1 1941	1.01
8	10724.	29.6	16.38	6.1	12 1931	.89
9	13518.	37.3	18.51	5.4	1 1931	.79
10	19435.	53.7	20.64	4.8	1 1939	.69
11	21656.	59.8	22.77	4.4	2 1970	.61
12	22637.	62.5	24.90	4.0	8 1934	.53
13	23649.	65.3	27.02	3.7	2 1938	.45
14	27887.	77.0	29.15	3.4	1 1962	.38
15	30485.	84.2	31.28	3.2	8 1932	.31
16	35361.	97.6	33.41	3.0	2 1971	.25
17	36810.	101.6	35.54	2.8	2 1957	.19
18	39539.	109.2	37.67	2.7	1 1942	.13
19	42304.	116.8	39.80	2.5	2 1949	.08
20	42741.	118.0	41.93	2.4	8 1933	.03
21	44900.	124.0	44.06	2.3	2 1950	-.03
22	53050.	146.5	46.19	2.2	2 1961	-.08
23	53111.	146.6	48.31	2.1	2 1968	-.13
24	54545.	150.6	50.44	2.0	3 1975	-.17

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	12325.	22.7	1.48	67.3	2 1933	2.83
2	12898.	23.7	3.63	27.6	2 1935	2.12
3	13351.	24.6	5.77	17.3	2 1937	1.75
4	14649.	27.0	7.91	12.6	2 1934	1.50
5	23322.	42.9	10.05	10.0	3 1940	1.30
6	31412.	57.8	12.19	8.2	3 1932	1.14
7	32700.	60.2	14.33	7.0	2 1936	1.01
8	35819.	65.9	16.47	6.1	3 1931	.89
9	39402.	72.5	18.61	5.4	2 1941	.78
10	52176.	96.0	20.75	4.8	4 1938	.69
11	56708.	104.4	22.89	4.4	3 1962	.60
12	58359.	107.4	25.03	4.0	2 1939	.52
13	70534.	129.8	27.17	3.7	3 1942	.45
14	82850.	152.5	29.31	3.4	3 1949	.38
15	94920.	174.7	31.45	3.2	4 1961	.31
16	95407.	175.6	33.59	3.0	3 1970	.25
17	96011.	176.7	35.73	2.8	3 1957	.19
18	112433.	206.9	37.87	2.6	3 1965	.13
19	114480.	210.7	40.01	2.5	4 1959	.07
20	116412.	214.2	42.15	2.4	4 1968	.02
21	117590.	216.4	44.29	2.3	5 1971	-.03
22	121911.	224.4	46.43	2.2	3 1964	-.08
23	139782.	257.3	48.57	2.1	3 1960	-.13
24	139802.	257.3	50.71	2.0	2 1950	-.18

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	29019.	40.1	1.49	67.0	6 1934	2.82
2	31223.	43.1	3.64	27.4	3 1933	2.12
3	53198.	73.4	5.80	17.3	3 1937	1.75
4	66209.	91.4	7.95	12.6	12 1931	1.49
5	76231.	105.2	10.10	9.9	3 1936	1.30
6	76593.	105.7	12.25	8.2	7 1940	1.14
7	94222.	130.1	14.40	6.9	11 1938	1.00
8	110704.	152.8	16.56	6.0	3 1962	.88
9	131170.	181.1	18.71	5.3	7 1941	.78
10	143426.	198.0	20.86	4.8	12 1930	.68
11	162685.	224.6	23.01	4.3	6 1949	.60
12	195467.	269.8	25.16	4.0	6 1971	.52
13	200418.	276.6	27.32	3.7	5 1959	.44
14	218228.	301.2	29.47	3.4	8 1968	.37
15	222816.	307.6	31.62	3.2	9 1976	.30
16	233140.	321.8	33.77	3.0	7 1955	.24
17	240023.	331.3	35.92	2.8	4 1957	.18
18	265379.	366.3	38.07	2.6	9 1973	.12
19	277756.	383.4	40.23	2.5	6 1970	.07
20	281982.	389.2	42.38	2.4	10 1964	.01
21	302327.	417.3	44.53	2.2	2 1961	-.04
22	327805.	452.5	46.68	2.1	7 1942	-.09
23	348392.	480.9	48.83	2.0	6 1946	-.14
24	371636.	513.0	50.99	2.0	3 1975	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	76784.	53.0	1.53	65.5	4 1934	2.81
2	129429.	89.3	3.72	26.8	3 1937	2.10
3	163449.	112.8	5.92	16.9	4 1932	1.73
4	191764.	132.3	8.12	12.3	5 1941	1.47
5	253465.	174.9	10.32	9.7	3 1939	1.28
6	417619.	288.2	12.52	8.0	3 1962	1.12
7	450764.	311.1	14.72	6.8	3 1960	.98
8	473223.	326.6	16.92	5.9	6 1971	.86
9	525144.	362.4	19.12	5.2	1 1950	.76
10	543135.	374.8	21.32	4.7	2 1957	.66
11	647580.	446.9	23.52	4.3	3 1965	.58
12	654825.	451.9	25.72	3.9	3 1975	.50
13	816564.	563.6	27.92	3.6	3 1969	.42
14	872107.	601.9	30.12	3.3	3 1947	.35
15	1017304.	702.1	32.31	3.1	2 1955	.28
16	1153083.	795.8	34.51	2.9	5 1943	.22
17	1342051.	926.2	36.71	2.7	1 1952	.16
18	1849848.	1276.7	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	183120.	63.2	1.60	62.7	2 1935	2.77
2	358926.	123.9	3.90	25.7	2 1939	2.06
3	852022.	294.0	6.20	16.1	3 1943	1.69
4	868383.	299.7	8.50	11.8	3 1962	1.44
5	1327943.	458.2	10.80	9.3	3 1958	1.24
6	1576619.	544.1	13.10	7.6	3 1950	1.08
7	1584226.	546.7	15.40	6.5	8 1973	.94
8	2421962.	835.8	17.70	5.7	10 1966	.83
9	3040363.	1049.2	20.00	5.0	3 1954	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	524296.	90.5	1.76	56.9	6 1938	2.69
2	2196326.	379.0	4.29	23.3	3 1962	1.99
3	3435180.	592.7	6.82	14.7	6 1946	1.62
4	4041808.	697.4	9.36	10.7	3 1975	1.36

INDEPENDENT EVENTS EXHAUSTED

1

Buffalo River at Dilworth - Year 2030 Case

BUFFALO RIVER AT DILWORTH / MOORHEAD / GLYNDON / KRAGNES

YEARS (RECORD) MONTHS DURATION IN MONTHS

47 0 2

EFFECTIVE YEARS

46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	60.	.5	1.47	68.2	9 1936	2.84
2	121.	1.0	3.58	27.9	2 1940	2.13
3	241.	2.0	5.69	17.6	2 1936	1.76
4	241.	2.0	7.81	12.8	9 1939	1.51
5	241.	2.0	9.92	10.1	2 1942	1.31
6	302.	2.5	12.04	8.3	8 1934	1.15
7	302.	2.5	14.15	7.1	9 1976	1.02
8	483.	4.0	16.26	6.1	3 1937	.90
9	543.	4.5	18.38	5.4	9 1932	.79
10	543.	4.5	20.49	4.9	2 1933	.70
11	543.	4.5	22.61	4.4	1 1938	.61
12	604.	5.0	24.72	4.0	2 1939	.53
13	724.	6.0	26.83	3.7	1 1937	.46
14	845.	7.0	28.95	3.5	9 1938	.39
15	906.	7.5	31.06	3.2	9 1930	.32
16	906.	7.5	33.18	3.0	9 1933	.26
17	906.	7.5	35.29	2.8	11 1936	.20
18	906.	7.5	37.40	2.7	10 1940	.14
19	966.	8.0	39.52	2.5	12 1932	.09
20	966.	8.0	41.63	2.4	12 1935	.03
21	966.	8.0	43.75	2.3	11 1939	-.02
22	966.	8.0	45.86	2.2	2 1950	-.07
23	966.	8.0	47.97	2.1	2 1963	-.12
24	1026.	8.5	50.09	2.0	8 1940	-.17

(continued)

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	181.	1.0	1.47	68.1	9 1936	2.83
2	241.	1.3	3.59	27.9	3 1940	2.13
3	543.	3.0	5.70	17.5	10 1939	1.76
4	604.	3.3	7.82	12.8	2 1936	1.51
5	664.	3.7	9.94	10.1	9 1934	1.31
6	845.	4.7	12.06	8.3	3 1937	1.15
7	845.	4.7	14.18	7.1	2 1938	1.01
8	906.	5.0	16.29	6.1	2 1933	.90
9	906.	5.0	18.41	5.4	2 1942	.79
10	906.	5.0	20.53	4.9	9 1976	.70
11	966.	5.3	22.65	4.4	9 1932	.61
12	1087.	6.0	24.76	4.0	2 1939	.53
13	1268.	7.0	26.88	3.7	12 1936	.46
14	1328.	7.3	29.00	3.4	10 1938	.39
15	1389.	7.7	31.12	3.2	9 1940	.32
16	1449.	8.0	33.23	3.0	9 1933	.26
17	1751.	9.7	35.35	2.8	2 1941	.20
18	1811.	10.0	37.47	2.7	2 1930	.14
19	1811.	10.0	39.59	2.5	9 1930	.08
20	1811.	10.0	41.71	2.4	2 1931	.03
21	1811.	10.0	43.82	2.3	1 1935	-.02
22	1932.	10.7	45.94	2.2	10 1931	-.07
23	2113.	11.7	48.06	2.1	2 1944	-.12
24	2113.	11.7	50.18	2.0	2 1949	-.17

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	543.	2.3	1.47	67.9	10 1936	2.83
2	724.	3.0	3.59	27.8	3 1940	2.13
3	1026.	4.3	5.71	17.5	10 1939	1.76
4	1207.	5.0	7.84	12.8	2 1936	1.50
5	1207.	5.0	9.96	10.0	3 1937	1.31
6	1509.	6.3	12.08	8.3	2 1933	1.15
7	1509.	6.3	14.20	7.0	2 1938	1.01
8	1570.	6.5	16.32	6.1	9 1934	.89
9	1751.	7.3	18.44	5.4	10 1932	.79
10	1751.	7.3	20.56	4.9	2 1939	.70
11	1932.	8.0	22.69	4.4	10 1940	.61
12	2355.	9.8	24.81	4.0	10 1933	.53
13	2355.	9.8	26.93	3.7	10 1938	.45
14	2355.	9.8	29.05	3.4	2 1942	.38
15	2355.	9.8	31.17	3.2	9 1976	.32
16	2596.	10.8	33.29	3.0	2 1930	.25
17	2596.	10.8	35.42	2.8	11 1930	.20
18	2656.	11.0	37.54	2.7	2 1941	.14
19	2717.	11.3	39.66	2.5	2 1935	.08
20	2958.	12.3	41.78	2.4	10 1931	.03
21	3079.	12.8	43.90	2.3	3 1962	-.02
22	3200.	13.3	46.02	2.2	2 1949	-.07
23	3260.	13.5	48.14	2.1	2 1932	-.12
24	3441.	14.3	50.27	2.0	10 1937	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	1449.	4.0	1.48	67.7	12 1936	2.83
2	1690.	4.7	3.61	27.7	2 1940	2.13
3	2596.	7.2	5.73	17.4	1 1933	1.76
4	2656.	7.3	7.86	12.7	2 1939	1.50
5	2777.	7.7	9.99	10.0	2 1936	1.31
6	3079.	8.5	12.12	8.2	12 1934	1.15
7	3079.	8.5	14.25	7.0	2 1938	1.01
8	3441.	9.5	16.38	6.1	12 1940	.89
9	3683.	10.2	18.51	5.4	1 1931	.79
10	4347.	12.0	20.64	4.8	12 1933	.69
11	4407.	12.2	22.77	4.4	2 1932	.61
12	4951.	13.7	24.90	4.0	2 1949	.53
13	5071.	14.0	27.02	3.7	2 1942	.45
14	5675.	15.7	29.15	3.4	2 1951	.38
15	5796.	16.0	31.28	3.2	2 1968	.31
16	5917.	16.3	33.41	3.0	1 1962	.25
17	6339.	17.5	35.54	2.8	1 1971	.19
18	6581.	18.2	37.67	2.7	2 1950	.13
19	7003.	19.3	39.80	2.5	4 1944	.08
20	7184.	19.8	41.93	2.4	2 1957	.03
21	7788.	21.5	44.06	2.3	2 1948	-.03
22	7969.	22.0	46.19	2.2	3 1930	-.08
23	7969.	22.0	48.31	2.1	3 1955	-.13
24	8090.	22.3	50.44	2.0	3 1965	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2294.	4.2	1.48	67.3	3 1937	2.83
2	2415.	4.4	3.63	27.6	3 1940	2.12
3	5192.	9.6	5.77	17.3	2 1933	1.75
4	5434.	10.0	7.91	12.6	2 1935	1.50
5	5675.	10.4	10.05	10.0	2 1941	1.30
6	7003.	12.9	12.19	8.2	2 1931	1.14
7	7366.	13.6	14.33	7.0	2 1934	1.01
8	7788.	14.3	16.47	6.1	2 1932	.89
9	7788.	14.3	18.61	5.4	2 1938	.78
10	7969.	14.7	20.75	4.8	3 1942	.69
11	8633.	15.9	22.89	4.4	3 1962	.60
12	8754.	16.1	25.03	4.0	2 1936	.52
13	9237.	17.0	27.17	3.7	2 1939	.45
14	9599.	17.7	29.31	3.4	3 1949	.38
15	10988.	20.2	31.45	3.2	3 1951	.31
16	13524.	24.9	33.59	3.0	3 1955	.25
17	13584.	25.0	35.73	2.8	3 1965	.19
18	15335.	28.2	37.87	2.6	3 1971	.13
19	15637.	28.8	40.01	2.5	3 1948	.07
20	16120.	29.7	42.15	2.4	2 1957	.02
21	17689.	32.6	44.29	2.3	3 1968	-.03
22	17870.	32.9	46.43	2.2	4 1944	-.08
23	18233.	33.6	48.57	2.1	2 1950	-.13
24	19199.	35.3	50.71	2.0	3 1969	-.18

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	14731.	20.3	1.49	67.0	3 1932	2.82
2	17569.	24.3	3.64	27.4	4 1937	2.12
3	17931.	24.8	5.80	17.3	1 1935	1.75
4	19319.	26.7	7.95	12.6	4 1940	1.49
5	19802.	27.3	10.10	9.9	4 1942	1.30
6	20225.	27.9	12.25	8.2	9 1930	1.14
7	20949.	28.9	14.40	6.9	4 1933	1.00
8	20949.	28.9	16.56	6.0	3 1936	.88
9	23606.	32.6	18.71	5.3	4 1938	.78
10	31334.	43.3	20.86	4.8	6 1949	.68
11	31877.	44.0	23.01	4.3	8 1973	.60
12	34473.	47.6	25.16	4.0	4 1941	.52
13	36526.	50.4	27.32	3.7	3 1962	.44
14	39363.	54.3	29.47	3.4	6 1971	.37
15	41718.	57.6	31.62	3.2	7 1968	.30
16	47151.	65.1	33.77	3.0	6 1955	.24
17	48359.	66.8	35.92	2.8	9 1976	.18
18	53490.	73.8	38.07	2.6	4 1939	.12
19	57052.	78.8	40.23	2.5	5 1957	.07
20	62124.	85.8	42.38	2.4	4 1970	.01
21	62546.	86.3	44.53	2.2	6 1944	-.04
22	62667.	86.5	46.68	2.1	6 1948	-.09
23	65625.	90.6	48.83	2.0	6 1946	-.14
24	75949.	104.8	50.99	2.0	3 1964	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	34896.	24.1	1.53	65.5	2 1933	2.81
2	41054.	28.3	3.72	26.8	5 1935	2.10
3	41174.	28.4	5.92	16.9	4 1938	1.73
4	48902.	33.8	8.12	12.3	3 1941	1.47
5	94001.	64.9	10.32	9.7	6 1949	1.28
6	99676.	68.8	12.52	8.0	3 1943	1.12
7	116218.	80.2	14.72	6.8	6 1971	.98
8	131492.	90.8	16.92	5.9	6 1955	.86
9	133243.	92.0	19.12	5.2	4 1962	.76
10	143024.	98.7	21.32	4.7	3 1974	.66
11	148819.	102.7	23.52	4.3	5 1958	.58
12	149544.	103.2	25.72	3.9	3 1969	.50
13	167052.	115.3	27.92	3.6	3 1947	.42
14	169346.	116.9	30.12	3.3	3 1965	.35
15	186251.	128.5	32.31	3.1	6 1952	.28
16	340021.	234.7	34.51	2.9	3 1967	.22
17	349439.	241.2	36.71	2.7	3 1945	.16
18	365136.	252.0	38.91	2.6	9 1976	.10

INDEPENDENT EVENTS EXHAUSTED
1

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	76191.	26.3	1.60	62.7	9 1934	2.77
2	111932.	38.6	3.90	25.7	5 1940	2.06
3	266003.	91.8	6.20	16.1	5 1944	1.69
4	287074.	99.1	8.50	11.8	3 1950	1.44
5	308204.	106.4	10.80	9.3	6 1971	1.24
6	324022.	111.8	13.10	7.6	3 1962	1.08
7	339779.	117.3	15.40	6.5	8 1957	.94
8	476222.	164.3	17.70	5.7	6 1975	.83
9	499707.	172.4	20.00	5.0	12 1966	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	190899.	32.9	1.76	56.9	4 1938	2.69
2	638807.	110.2	4.29	23.3	5 1946	1.99
3	697550.	120.4	6.82	14.7	3 1962	1.62
4	742769.	128.2	9.36	10.7	3 1975	1.36

INDEPENDENT EVENTS EXHAUSTED

1

South Branch Buffalo River at Sabin - Year 2030 and 1980 Cases

BUFFALO RIVER AT SABIN

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	0	0	1.47	68.2	2 1930	2.84
2	0	0	3.58	27.9	1 1931	2.13
3	0	0	5.69	17.6	8 1932	1.76
4	0	0	7.81	12.8	1 1933	1.51
5	0	0	9.92	10.1	2 1934	1.31
6	0	0	12.04	8.3	8 1934	1.15
7	0	0	14.15	7.1	2 1935	1.02
8	0	0	16.26	6.1	2 1936	.90
9	0	0	18.38	5.4	8 1936	.79
10	0	0	20.49	4.9	2 1937	.70
11	0	0	22.61	4.4	1 1938	.61
12	0	0	24.72	4.0	2 1939	.53
13	0	0	26.83	3.7	8 1939	.46
14	0	0	28.95	3.5	2 1940	.39
15	0	0	31.06	3.2	10 1940	.32
16	0	0	33.18	3.0	1 1941	.26
17	0	0	35.29	2.8	8 1941	.20
18	0	0	37.40	2.7	1 1942	.14
19	0	0	39.52	2.5	2 1943	.09
20	0	0	41.63	2.4	2 1944	.03
21	0	0	43.75	2.3	1 1946	-.02
22	0	0	45.86	2.2	1 1948	-.07
23	0	0	47.97	2.1	2 1949	-.12
24	0	0	50.09	2.0	2 1950	-.17

(continued)

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	0	0	1.47	68.1	2 1931	2.83
2	0	0	3.59	27.9	2 1933	2.13
3	0	0	5.70	17.5	9 1934	1.76
4	0	0	7.82	12.8	9 1936	1.51
5	0	0	9.94	10.1	3 1937	1.31
6	0	0	12.06	8.3	2 1938	1.15
7	0	0	14.18	7.1	9 1939	1.01
8	0	0	16.29	6.1	3 1940	.90
9	0	0	18.41	5.4	2 1941	.79
10	0	0	20.53	4.9	2 1942	.70
11	0	0	22.65	4.4	2 1946	.61
12	0	0	24.76	4.0	2 1948	.53
13	0	0	26.88	3.7	3 1949	.46
14	0	0	29.00	3.4	3 1951	.39
15	0	0	31.12	3.2	2 1956	.32
16	0	0	33.23	3.0	3 1962	.26
17	0	0	35.35	2.8	2 1965	.20
18	60.	.3	37.47	2.7	9 1932	.14
19	60.	.3	39.59	2.5	3 1934	.08
20	60.	.3	41.71	2.4	2 1939	.03
21	60.	.3	43.82	2.3	9 1940	-.02
22	60.	.3	45.94	2.2	2 1961	-.07
23	60.	.3	48.06	2.1	3 1969	-.12
24	60.	.3	50.18	2.0	3 1975	-.17

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	0	0	1.47	67.9	3 1956	2.83
2	0	0	3.59	27.8	3 1965	2.13
3	60.	.3	5.71	17.5	2 1933	1.76
4	60.	.3	7.84	12.8	9 1936	1.50
5	60.	.3	9.96	10.0	2 1938	1.31
6	60.	.3	12.08	8.3	9 1939	1.15
7	60.	.3	14.20	7.0	3 1940	1.01
8	60.	.3	16.32	6.1	10 1940	.89
9	60.	.3	18.44	5.4	3 1951	.79
10	121.	.5	20.56	4.9	2 1931	.70
11	121.	.5	22.69	4.4	9 1934	.61
12	121.	.5	24.81	4.0	3 1949	.53
13	121.	.5	26.93	3.7	9 1976	.45
14	181.	.8	29.05	3.4	3 1937	.38
15	181.	.8	31.17	3.2	2 1941	.32
16	181.	.8	33.29	3.0	2 1942	.25
17	181.	.8	35.42	2.8	2 1948	.20
18	181.	.8	37.54	2.7	3 1962	.14
19	241.	1.0	39.66	2.5	3 1975	.08
20	302.	1.3	41.78	2.4	2 1946	.03
21	362.	1.5	43.90	2.3	3 1934	-.02
22	362.	1.5	46.02	2.2	10 1937	-.07
23	362.	1.5	48.14	2.1	2 1939	-.12
24	423.	1.8	50.27	2.0	9 1932	-.17

(continued)

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	181.	.5	1.48	67.7	2 1941	2.83
2	241.	.7	3.61	27.7	11 1939	2.13
3	302.	.8	5.73	17.4	2 1938	1.76
4	362.	1.0	7.86	12.7	11 1936	1.50
5	362.	1.0	9.99	10.0	3 1956	1.31
6	483.	1.3	12.12	8.2	12 1932	1.15
7	483.	1.3	14.25	7.0	2 1949	1.01
8	483.	1.3	16.38	6.1	3 1951	.89
9	604.	1.7	18.51	5.4	2 1939	.79
10	604.	1.7	20.64	4.8	2 1950	.69
11	664.	1.8	22.77	4.4	2 1948	.61
12	724.	2.0	24.90	4.0	12 1941	.53
13	785.	2.2	27.02	3.7	3 1931	.45
14	785.	2.2	29.15	3.4	2 1954	.38
15	785.	2.2	31.28	3.2	2 1957	.31
16	845.	2.3	33.41	3.0	2 1936	.25
17	906.	2.5	35.54	2.8	11 1934	.19
18	966.	2.7	37.67	2.7	3 1965	.13
19	1087.	3.0	39.80	2.5	2 1932	.08
20	1087.	3.0	41.93	2.4	3 1934	.03
21	1087.	3.0	44.06	2.3	2 1946	-.03
22	1087.	3.0	46.19	2.2	3 1962	-.08
23	1207.	3.3	48.31	2.1	3 1964	-.13
24	1207.	3.3	50.44	2.0	2 1971	-.17

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	241.	.4	1.48	67.3	3 1940	2.83
2	302.	.6	3.63	27.6	2 1941	2.12
3	483.	.9	5.77	17.3	3 1937	1.75
4	845.	1.6	7.91	12.6	2 1933	1.50
5	845.	1.6	10.05	10.0	3 1949	1.30
6	966.	1.8	12.19	8.2	3 1951	1.14
7	1026.	1.9	14.33	7.0	2 1935	1.01
8	1026.	1.9	16.47	6.1	2 1938	.89
9	1268.	2.3	18.61	5.4	3 1942	.78
10	1509.	2.8	20.75	4.8	2 1932	.69
11	1570.	2.9	22.89	4.4	2 1936	.60
12	1630.	3.0	25.03	4.0	3 1934	.52
13	1630.	3.0	27.17	3.7	3 1962	.45
14	1872.	3.4	29.31	3.4	2 1939	.38
15	1992.	3.7	31.45	3.2	3 1965	.31
16	2294.	4.2	33.59	3.0	3 1975	.25
17	2415.	4.4	35.73	2.8	2 1957	.19
18	2475.	4.6	37.87	2.6	2 1950	.13
19	3200.	5.9	40.01	2.5	5 1931	.07
20	3441.	6.3	42.15	2.4	3 1964	.02
21	3502.	6.4	44.29	2.3	3 1955	-.03
22	3985.	7.3	46.43	2.2	2 1946	-.08
23	4166.	7.7	48.57	2.1	3 1968	-.13
24	4286.	7.9	50.71	2.0	3 1952	-.18

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2415.	3.3	1.49	67.0	9 1931	2.82
2	4105.	5.7	3.64	27.4	3 1934	2.12
3	4226.	5.8	5.80	17.3	4 1937	1.75
4	4407.	6.1	7.95	12.6	4 1942	1.49
5	4649.	6.4	10.10	9.9	3 1936	1.30
6	5071.	7.0	12.25	8.2	2 1933	1.14
7	7184.	9.9	14.40	6.9	3 1940	1.00
8	7547.	10.4	16.56	6.0	3 1974	.88
9	8030.	11.1	18.71	5.3	6 1949	.78
10	8211.	11.3	20.86	4.8	3 1935	.68
11	10626.	14.7	23.01	4.3	3 1962	.60
12	11109.	15.3	25.16	4.0	9 1930	.52
13	11773.	16.3	27.32	3.7	9 1976	.44
14	11833.	16.3	29.47	3.4	4 1938	.37
15	12195.	16.8	31.62	3.2	6 1971	.30
16	12739.	17.6	33.77	3.0	3 1941	.24
17	12859.	17.8	35.92	2.8	6 1968	.18
18	15335.	21.2	38.07	2.6	3 1955	.12
19	15757.	21.8	40.23	2.5	3 1947	.07
20	18414.	25.4	42.38	2.4	4 1970	.01
21	19440.	26.8	44.53	2.2	5 1957	-.04
22	20346.	28.1	46.68	2.1	4 1944	-.09
23	21795.	30.1	48.83	2.0	6 1958	-.14
24	22459.	31.0	50.99	2.0	6 1948	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	8090.	5.6	1.53	65.5	9 1932	2.81
2	12316.	8.5	3.72	26.8	3 1935	2.10
3	16059.	11.1	5.92	16.9	4 1938	1.73
4	18414.	12.7	8.12	12.3	4 1942	1.47
5	30488.	21.0	10.32	9.7	6 1949	1.28
6	31696.	21.9	12.52	8.0	3 1975	1.12
7	32662.	22.5	14.72	6.8	4 1940	.98
8	34473.	23.8	16.92	5.9	5 1971	.86
9	37673.	26.0	19.12	5.2	6 1955	.76
10	41356.	28.5	21.32	4.7	5 1958	.66
11	46427.	32.0	23.52	4.3	3 1947	.58
12	47151.	32.5	25.72	3.9	4 1962	.50
13	50230.	34.7	27.92	3.6	3 1969	.42
14	62063.	42.8	30.12	3.3	3 1965	.35
15	67014.	46.3	32.31	3.1	5 1944	.28
16	70455.	48.6	34.51	2.9	4 1953	.22
17	137349.	94.8	36.71	2.7	3 1967	.16

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	32481.	11.2	1.60	62.7	9 1934	2.77
2	41718.	14.4	3.90	25.7	12 1938	2.06
3	55121.	19.0	6.20	16.1	3 1943	1.69
4	90378.	31.2	8.50	11.8	3 1950	1.44
5	98710.	34.1	10.80	9.3	8 1973	1.24
6	102030.	35.2	13.10	7.6	6 1957	1.08
7	116158.	40.1	15.40	6.5	3 1962	.94
8	183474.	63.3	17.70	5.7	5 1968	.83

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	71482.	12.3	1.76	56.9	12 1937	2.69
2	208649.	36.0	4.29	23.3	12 1945	1.99
3	224648.	38.8	6.82	14.7	3 1962	1.62
4	239137.	41.3	9.36	10.7	3 1975	1.36
5	296371.	51.1	11.89	8.4	3 1954	1.16

1

RESULTS OF YEAR 1980 PARTIAL DURATION ANALYSES

Sheyenne River at Horace - Year 1980 Case

YEAR 1980 SHEYENNE RIVER AT HORACE

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	480.	4.0	1.47	68.2	8 1930	2.84
2	601.	5.0	3.58	27.9	8 1933	2.13
3	661.	5.5	5.69	17.6	8 1938	1.76
4	661.	5.5	7.81	12.8	8 1940	1.51
5	817.	6.8	9.92	10.1	6 1934	1.31
6	842.	7.0	12.04	8.3	8 1961	1.15
7	881.	7.3	14.15	7.1	9 1937	1.02
8	896.	7.4	16.26	6.1	3 1941	.90
9	942.	7.8	18.38	5.4	9 1967	.79
10	956.	7.9	20.49	4.9	11 1935	.70
11	956.	7.9	22.61	4.4	2 1940	.61
12	963.	8.0	24.72	4.0	8 1939	.53
13	963.	8.0	26.83	3.7	8 1931	.46
14	1017.	8.4	28.95	3.5	2 1937	.39
15	1017.	8.4	31.06	3.2	1 1935	.32
16	1244.	10.3	33.18	3.0	9 1959	.26
17	1425.	11.8	35.29	2.8	9 1958	.20
18	1425.	11.8	37.40	2.7	9 1952	.14
19	1439.	11.9	39.52	2.5	1 1939	.09
20	1533.	12.7	41.63	2.4	10 1938	.03
21	1620.	13.4	43.75	2.3	11 1937	-.02
22	1620.	13.4	45.86	2.2	1 1934	-.07
23	1666.	13.8	47.97	2.1	9 1968	-.12
24	1741.	14.4	50.09	2.0	11 1931	-.17

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL F
1	1052.	5.8	1.47	68.1	9 1938	2.83
2	1414.	7.8	3.59	27.9	9 1961	2.17
3	1535.	8.5	5.70	17.5	9 1930	1.76
4	1591.	8.8	7.82	12.8	7 1934	1.51
5	1595.	8.8	9.94	10.1	9 1937	1.31
6	1736.	9.6	12.06	8.3	2 1940	1.15
7	1736.	9.6	14.18	7.1	2 1937	1.01
8	1917.	10.6	16.29	6.1	3 1941	.90
9	1951.	10.8	18.41	5.4	11 1935	.79
10	2078.	11.5	20.53	4.9	9 1958	.70
11	2093.	11.6	22.65	4.4	8 1939	.61
12	2099.	11.6	24.76	4.0	2 1935	.53
13	2280.	12.6	26.88	3.7	2 1939	.46
14	2395.	13.2	29.00	3.4	8 1940	.39
15	2501.	13.8	31.12	3.2	9 1967	.32
16	2521.	13.9	33.23	3.0	12 1937	.26
17	2682.	14.8	35.35	2.8	9 1933	.20
18	2742.	15.1	37.47	2.7	9 1959	.14
19	2863.	15.8	39.59	2.5	9 1931	.08
20	3004.	16.6	41.71	2.4	1 1934	.03
21	3165.	17.5	43.82	2.3	9 1973	-.02
22	3366.	18.6	45.94	2.2	1 1962	-.07
23	3729.	20.6	48.06	2.1	12 1931	-.12
24	3829.	21.1	50.18	2.0	9 1947	-.17

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2122.	8.8	1.47	67.9	9 1938	2.83
2	2435.	10.1	3.59	27.8	10 1937	2.13
3	2758.	11.4	5.71	17.5	3 1941	1.76
4	2879.	11.9	7.84	12.8	3 1940	1.50
5	3180.	13.2	9.96	10.0	3 1937	1.31
6	3220.	13.3	12.08	8.3	10 1930	1.15
7	3329.	13.8	14.20	7.0	9 1961	1.01
8	3362.	13.9	16.32	6.1	2 1935	.89
9	3455.	14.3	18.44	5.4	12 1935	.79
10	3482.	14.4	20.56	4.9	2 1939	.70
11	3531.	14.6	22.69	4.4	8 1934	.61
12	3643.	15.1	24.81	4.0	10 1958	53
13	3764.	15.6	26.93	3.7	10 1933	.45
14	3933.	16.3	29.05	3.4	9 1939	.38
15	3951.	16.4	31.17	3.2	11 1931	.32
16	4355.	18.0	33.29	3.0	9 1940	.25
17	4373.	18.1	35.42	2.8	11 1959	.20
18	4856.	20.1	37.54	2.7	11 1973	.14
19	5354.	22.2	39.66	2.5	1 1962	.08
20	5635.	23.3	41.78	2.4	10 1967	.03
21	5930.	24.6	43.90	2.3	12 1963	-.02
22	6480.	26.8	46.02	2.2	10 1936	-.07
23	6728.	27.9	48.14	2.1	11 1932	-.12
24	8240.	34.1	50.27	2.0	8 1957	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4116.	11.4	1.48	67.7	12 1938	2.83
2	4116.	11.4	3.61	27.7	12 1937	2.13
3	5465.	15.1	5.73	17.4	3 1940	1.76
4	5746.	15.9	7.86	12.7	12 1933	1.50
5	5807.	16.0	9.99	10.0	12 1961	1.31
6	6592.	18.2	12.12	8.2	12 1935	1.15
7	6592.	18.2	14.25	7.0	12 1931	1.01
8	6672.	18.4	16.38	6.1	4 1937	.89
9	7249.	20.0	18.51	5.4	2 1935	.79
10	8391.	23.2	20.64	4.8	11 1973	.69
11	8463.	23.4	22.77	4.4	12 1963	.61
12	8572.	23.7	24.90	4.0	11 1959	.53
13	9833.	27.1	27.02	3.7	9 1940	.45
14	11442.	31.6	29.15	3.4	3 1941	.38
15	11892.	32.8	31.28	3.2	11 1932	.31
16	11946.	33.0	33.41	3.0	10 1958	.25
17	12577.	34.7	35.54	2.8	8 1934	.19
18	14119.	39.0	37.67	2.7	10 1936	.13
19	14965.	41.3	39.80	2.5	9 1939	.08
20	15708.	43.4	41.93	2.4	12 1930	.03
21	19278.	53.2	44.06	2.3	8 1957	-.03
22	20115.	55.5	46.19	2.2	12 1967	-.08
23	20600.	56.9	48.31	2.1	6 1938	-.13
24	23979.	66.2	50.44	2.0	12 1960	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS

47 0 9

EFFECTIVE YEARS

46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	6746.	12.4	1.48	67.3	2 1939	2.83
2	8255.	15.2	3.63	27.6	2 1940	2.12
3	9698.	17.8	5.77	17.3	1 1935	1.75
4	11588.	21.3	7.91	12.6	3 1937	1.50
5	11871.	21.8	10.05	10.0	12 1937	1.30
6	12173.	22.4	12.19	8.2	1 1962	1.14
7	12897.	23.7	14.33	7.0	1 1932	1.01
8	14063.	25.9	16.47	6.1	3 1941	.89
9	15131.	27.8	18.61	5.4	1 1934	.78
10	19901.	36.6	20.75	4.8	11 1959	.69
11	20082.	37.0	22.89	4.4	1 1936	.60
12	21791.	40.1	25.03	4.0	3 1964	.52
13	24127.	44.4	27.17	3.7	1 1974	.45
14	27327.	50.3	29.31	3.4	11 1932	.38
15	29923.	55.1	31.45	3.2	1 1959	.31
16	34107.	62.8	33.59	3.0	3 1931	.25
17	39549.	72.8	35.73	2.8	8 1957	.19
18	42016.	77.3	37.87	2.6	3 1968	.13
19	42378.	78.0	40.01	2.5	3 1948	.07
20	43646.	80.3	42.15	2.4	3 1946	.02
21	43646.	80.3	44.29	2.3	3 1975	-.03
22	43888.	80.8	46.43	2.2	3 1956	-.08
23	44974.	82.8	48.57	2.1	3 1947	-.13
24	46665.	85.9	50.71	2.0	3 1961	-.18

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS

47 0 12

EFFECTIVE YEARS

46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	14151.	19.5	1.49	67.0	11 1937	2.82
2	14573.	20.1	3.64	27.4	4 1940	2.12
3	15781.	21.8	5.80	17.3	3 1939	1.75
4	19826.	27.4	7.95	12.6	2 1935	1.49
5	29184.	40.3	10.10	9.9	3 1962	1.30
6	29969.	41.4	12.25	8.2	2 1932	1.14
7	35342.	48.8	14.40	6.9	12 1959	1.00
8	35764.	49.4	16.56	6.0	4 1936	.88
9	40292.	55.6	18.71	5.3	6 1964	.78
10	43552.	60.1	20.86	4.8	3 1974	.68
11	43794.	60.4	23.01	4.3	2 1934	.60
12	48262.	66.6	25.16	4.0	2 1933	.52
13	51884.	71.6	27.32	3.7	4 1941	.44
14	57921.	79.9	29.47	3.4	7 1957	.37
15	58948.	81.4	31.62	3.2	12 1958	.30
16	70660.	97.5	33.77	3.0	6 1968	.24
17	72350.	99.9	35.92	2.8	5 1953	.18
18	75490.	104.2	38.07	2.6	3 1946	.12
19	77965.	107.6	40.23	2.5	5 1954	.07
20	78388.	108.2	42.38	2.4	3 1956	.01
21	82674.	114.1	44.53	2.2	3 1947	-.04
22	82795.	114.3	46.68	2.1	8 1944	-.09
23	84727.	116.9	48.83	2.0	4 1942	-.14
24	99035.	136.7	50.99	2.0	2 1931	-.19

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	35003.	24.2	1.53	65.5	4 1940	2.81
2	48104.	33.2	3.72	26.8	4 1938	2.10
3	48889.	33.7	5.92	16.9	5 1935	1.73
4	78230.	54.0	8.12	12.3	2 1933	1.47
5	86018.	59.4	10.32	9.7	3 1960	1.28
6	122121.	84.3	12.52	8.0	3 1965	1.12
7	130332.	89.9	14.72	6.8	4 1962	.98
8	136611.	94.3	16.92	5.9	4 1942	.86
9	150315.	103.7	19.12	5.2	5 1954	.76
10	158164.	109.2	21.32	4.7	3 1947	.66
11	180442.	124.5	23.52	4.3	8 1957	.58
12	203263.	140.3	25.72	3.9	3 1974	.50
13	242445.	167.3	27.92	3.6	3 1969	.42
14	288992.	199.4	30.12	3.3	7 1944	.35
15	304508.	210.2	32.31	3.1	5 1971	.28
16	332944.	229.8	34.51	2.9	3 1949	.22
17	369651.	255.1	36.71	2.7	5 1952	.16
18	439140.	303.1	38.91	2.6	7 1976	.10
19	461599.	318.6	41.11	2.4	3 1967	.05

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	78700.	27.2	1.60	62.7	8 1940	2.77
2	140824.	48.6	3.90	25.7	3 1935	2.06
3	237843.	82.1	6.20	16.1	3 1962	1.69
4	353638.	122.0	8.50	11.8	4 1956	1.44
5	356053.	122.9	10.80	9.3	3 1948	1.24
6	540251.	186.4	13.10	7.6	2 1974	1.08
7	572189.	197.4	15.40	6.5	12 1966	.94
8	908889.	313.6	17.70	5.7	4 1952	.83

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	196702.	33.9	1.76	56.9	3 1941	2.69
2	643161.	111.0	4.29	23.3	2 1962	1.99
3	1009927.	174.3	6.82	14.7	3 1949	1.62
4	1273636.	219.8	9.36	10.7	12 1970	1.36

INDEPENDENT EVENTS EXHAUSTED

Sheyenne River at West Fargo - Year 1980 Case

YEAR 1980 SHEYENNE RIVER AT WEST FARGO/RIVERSIDE

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	816.	6.8	1.47	68.2	11 1935	2.84
2	817.	6.8	3.58	27.9	1 1935	2.13
3	876.	7.3	5.69	17.6	11 1932	1.76
4	922.	7.6	7.81	12.8	9 1976	1.51
5	970.	8.0	9.92	10.1	10 1936	1.31
6	977.	8.1	12.04	8.3	7 1934	1.15
7	1030.	8.5	14.15	7.1	10 1934	1.02
8	1043.	8.6	16.26	6.1	9 1939	.90
9	1043.	8.6	18.38	5.4	9 1940	.79
10	1043.	8.6	20.49	4.9	9 1933	.70
11	1058.	8.8	22.61	4.4	3 1941	.61
12	1122.	9.3	24.72	4.0	8 1961	.53
13	1122.	9.3	26.83	3.7	8 1931	.46
14	1163.	9.6	28.95	3.5	9 1932	.39
15	1239.	10.3	31.06	3.2	2 1940	.32
16	1240.	10.3	33.18	3.0	1 1937	.26
17	1243.	10.3	35.29	2.8	8 1936	.20
18	1243.	10.3	37.40	2.7	8 1937	.14
19	1540.	12.8	39.52	2.5	11 1931	.09
20	1545.	12.8	41.63	2.4	8 1938	.03
21	1545.	12.8	43.75	2.3	8 1930	-.02
22	1634.	13.5	45.86	2.2	10 1937	-.07
23	1646.	13.6	47.97	2.1	9 1952	-.12
24	1713.	14.3	50.09	2.0	1 1934	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL F
1	1438.	7.9	1.47	68.1	11 1932	2.83
2	1511.	8.3	3.59	27.9	10 1936	2.13
3	1518.	8.4	5.70	17.5	8 1934	1.76
4	1588.	8.8	7.82	12.8	2 1935	1.51
5	1619.	8.9	9.94	10.1	11 1935	1.31
6	1684.	9.3	12.06	8.3	9 1939	1.15
7	1684.	9.3	14.18	7.1	9 1940	1.01
8	1684.	9.3	16.29	6.1	9 1931	.90
9	1805.	10.0	18.41	5.4	9 1961	.79
10	1889.	10.4	20.53	4.9	3 1940	.70
11	1890.	10.4	22.65	4.4	2 1937	.61
12	1926.	10.6	24.76	4.0	9 1976	.53
13	1933.	10.7	26.88	3.7	10 1933	.46
14	2047.	11.3	29.00	3.4	9 1937	.39
15	2163.	11.9	31.12	3.2	11 1934	.32
16	2191.	12.1	33.23	3.0	3 1941	.26
17	2288.	12.6	35.35	2.8	9 1938	.20
18	2590.	14.3	37.47	2.7	9 1930	.14
19	2613.	14.4	39.59	2.5	12 1937	.08
20	2795.	15.4	41.71	2.4	2 1939	.03
21	2916.	16.1	43.82	2.3	1 1934	-.02
22	3398.	18.8	45.94	2.2	12 1939	-.07
23	3458.	19.1	48.06	2.1	12 1940	-.12
24	3579.	19.8	50.18	2.0	12 1931	-.17

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL
1	2019.	8.4	1.47	67.9	9 1934	2.83
2	2039.	8.4	3.59	27.8	11 1932	2.13
3	2213.	9.2	5.71	17.5	10 1936	1.76
4	2478.	10.3	7.84	12.8	1 1935	1.50
5	2696.	11.2	9.96	10.0	10 1940	1.31
6	2704.	11.2	12.08	8.3	11 1931	1.15
7	2756.	11.4	14.20	7.0	10 1939	1.01
8	2841.	11.8	16.32	6.1	3 1940	.89
9	2877.	11.9	18.44	5.4	10 1937	.79
10	3115.	12.9	20.56	4.9	12 1935	.70
11	3126.	12.9	22.69	4.4	11 1933	.61
12	3264.	13.5	24.81	4.0	3 1937	.53
13	3299.	13.7	26.93	3.7	10 1938	.45
14	3324.	13.8	29.05	3.4	3 1941	.38
15	4012.	16.6	31.17	3.2	9 1961	.32
16	4049.	16.8	33.29	3.0	2 1939	.25
17	4265.	17.7	35.42	2.8	10 1930	.20
18	4817.	19.9	37.54	2.7	11 1959	.14
19	5859.	24.3	39.66	2.5	1 1962	.08
20	6254.	25.9	41.78	2.4	12 1963	.03
21	6741.	27.9	43.90	2.3	10 1958	-.02
22	8491.	35.2	46.02	2.2	10 1967	-.07
23	9820.	40.7	48.14	2.1	10 1960	-.12
24	10170.	42.1	50.27	2.0	9 1976	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	3311.	9.1	1.48	67.7	10 1934	2.83
2	4660.	12.9	3.61	27.7	12 1937	2.13
3	4668.	12.9	5.73	17.4	1 1937	1.76
4	4849.	13.4	7.86	12.7	1 1934	1.50
5	4970.	13.7	9.99	10.0	1 1940	1.31
6	5143.	14.2	12.12	8.2	12 1940	1.15
7	5263.	14.5	14.25	7.0	12 1931	1.01
8	5444.	15.0	16.38	6.1	12 1938	.89
9	6652.	18.4	18.51	5.4	12 1961	.79
10	8631.	23.8	20.64	4.8	11 1932	.69
11	8946.	24.7	22.77	4.4	12 1935	.61
12	9127.	25.2	24.90	4.0	12 1963	.53
13	10637.	29.4	27.02	3.7	12 1959	.45
14	12894.	35.6	29.15	3.4	4 1935	.38
15	15929.	44.0	31.28	3.2	10 1958	.31
16	17023.	47.0	33.41	3.0	11 1930	.25
17	20593.	56.8	35.54	2.8	7 1939	.19
18	23442.	64.7	37.67	2.7	8 1957	.13
19	23737.	65.5	39.80	2.5	12 1967	.08
20	23740.	65.5	41.93	2.4	6 1938	.03
21	24462.	67.5	44.06	2.3	12 1960	-.03
22	26825.	74.1	46.19	2.2	1 1974	-.08
23	27294.	75.3	48.31	2.1	7 1936	-.13
24	27541.	76.0	50.44	2.0	12 1974	-.17

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	5261.	9.7	1.48	67.3	1 1935	2.83
2	6971.	12.8	3.63	27.6	3 1940	2.12
3	7334.	13.5	5.77	17.3	3 1941	1.75
4	7394.	13.6	7.91	12.6	3 1937	1.50
5	9253.	17.0	10.05	10.0	2 1939	1.30
6	11780.	21.7	12.19	8.2	12 1937	1.14
7	14015.	25.8	14.33	7.0	1 1962	1.01
8	14981.	27.6	16.47	6.1	1 1932	.89
9	15665.	28.8	18.61	5.4	3 1934	.78
10	23011.	42.3	20.75	4.8	1 1936	.69
11	23574.	43.4	22.89	4.4	3 1964	.60
12	25122.	46.2	25.03	4.0	11 1959	.52
13	26512.	48.8	27.17	3.7	1 1933	.45
14	34300.	63.1	29.31	3.4	1 1959	.38
15	38909.	71.6	31.45	3.2	3 1931	.31
16	43444.	80.0	33.59	3.0	8 1957	.25
17	45187.	83.2	35.73	2.8	3 1946	.19
18	46093.	84.8	37.87	2.6	3 1975	.13
19	46334.	85.3	40.01	2.5	3 1956	.07
20	46395.	85.4	42.15	2.4	3 1968	.02
21	46455.	85.5	44.29	2.3	3 1974	-.03
22	48025.	88.4	46.43	2.2	3 1948	-.08
23	48085.	88.5	48.57	2.1	3 1961	-.13
24	51044.	93.9	50.71	2.0	3 1947	-.18

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
17   0   12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	14031.	19.4	1.49	67.0	11 1940	2.82
2	14152.	19.5	3.64	27.4	11 1937	2.12
3	15299.	21.1	5.80	17.3	3 1935	1.75
4	21035.	29.0	7.95	12.6	2 1939	1.49
5	27434.	37.9	10.10	9.9	3 1962	1.30
6	35766.	49.4	12.25	8.2	2 1932	1.14
7	37396.	51.6	14.40	6.9	9 1936	1.00
8	38784.	53.5	16.56	6.0	3 1934	.88
9	40958.	56.5	18.71	5.3	12 1959	.78
10	44218.	61.0	20.86	4.8	6 1964	.68
11	60820.	84.0	23.01	4.3	2 1933	.60
12	61666.	85.1	25.16	4.0	7 1957	.52
13	64684.	89.3	27.32	3.7	12 1958	.44
14	75672.	104.5	29.47	3.4	6 1968	.37
15	82011.	113.2	31.62	3.2	3 1946	.30
16	82494.	113.9	33.77	3.0	3 1956	.24
17	83098.	114.7	35.92	2.8	5 1953	.18
18	83581.	115.4	38.07	2.6	6 1954	.12
19	91731.	126.6	40.23	2.5	4 1942	.07
20	99036.	136.7	42.38	2.4	3 1947	.01
21	100485.	138.7	44.53	2.2	7 1944	-.04
22	112500.	155.3	46.68	2.1	3 1974	-.09
23	117994.	162.9	48.83	2.0	12 1960	-.14
24	118054.	163.0	50.99	2.0	2 1931	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	36454.	25.2	1.53	65.5	3 1941	2.81
2	42794.	29.5	3.72	26.8	7 1938	2.10
3	45752.	31.6	5.92	16.9	5 1935	1.73
4	96586.	66.7	8.12	12.3	2 1933	1.47
5	96646.	66.7	10.32	9.7	3 1960	1.28
6	129187.	89.2	12.52	8.0	3 1965	1.12
7	132025.	91.1	14.72	6.8	4 1962	.98
8	177124.	122.2	16.92	5.9	5 1954	.86
9	181048.	125.0	19.12	5.2	3 1947	.76
10	186361.	128.6	21.32	4.7	8 1957	.66
11	226690.	156.5	23.52	4.3	3 1943	.58
12	257238.	177.5	25.72	3.9	3 1969	.50
13	319725.	220.7	27.92	3.6	9 1971	.42
14	330411.	228.0	30.12	3.3	3 1975	.35
15	355224.	245.2	32.31	3.1	3 1945	.28
16	370076.	255.4	34.51	2.9	4 1949	.22
17	376656.	260.0	36.71	2.7	5 1952	.16
18	470476.	324.7	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

YEARS (RECORD) MONTHS　　DURATION IN MONTHS
47　　0　　48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	83293.	28.7	1.60	62.7	11 1940	2.77
2	157310.	54.3	3.90	25.7	9 1936	2.06
3	247870.	85.5	6.20	16.1	3 1962	1.69
4	376525.	129.9	8.50	11.8	8 1957	1.44
5	426815.	147.3	10.80	9.3	3 1948	1.24
6	592600.	204.5	13.10	7.6	12 1966	1.08
7	671266.	231.6	15.40	6.5	5 1971	.94
8	784163.	270.6	17.70	5.7	5 1953	.83
9	800585.	276.3	20.00	5.0	5 1975	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS　　DURATION IN MONTHS
47　　0　　96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	202568.	35.0	1.76	56.9	3 1941	2.69
2	663637.	114.5	4.29	23.3	3 1962	1.99
3	1149519.	198.3	6.82	14.7	3 1949	1.62
4	1291335.	222.8	9.36	10.7	12 1970	1.36

INDEPENDENT EVENTS EXHAUSTED

Sheyenne River at Reile's Acres - Year 1980 Case

YEAR 1980 SHEYENNE RIVER AT REILE'S ACRES/HARWOOD/ARGUSVILLE

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL
1	656.	5.4	1.47	68.2	11 1935	2.84
2	793.	6.6	3.58	27.9	8 1961	2.13
3	793.	6.6	5.69	17.6	8 1931	1.76
4	826.	6.8	7.81	12.8	1 1935	1.51
5	958.	7.9	9.92	10.1	11 1932	1.31
6	974.	8.1	12.04	8.3	8 1939	1.15
7	997.	8.3	14.15	7.1	9 1976	1.02
8	997.	8.3	16.26	6.1	2 1940	.90
9	997.	8.3	18.38	5.4	9 1940	.79
10	997.	8.3	20.49	4.9	9 1933	.70
11	1012.	8.4	22.61	4.4	10 1936	.61
12	1058.	8.8	24.72	4.0	2 1937	.57
13	1058.	8.8	26.83	3.7	9 1934	.46
14	1215.	10.1	28.95	3.5	8 1936	.39
15	1239.	10.3	31.06	3.2	9 1932	.32
16	1336.	11.1	33.18	3.0	8 1938	.26
17	1336.	11.1	35.29	2.8	8 1937	.20
18	1490.	12.3	37.40	2.7	1 1934	.14
19	1495.	12.4	39.52	2.5	10 1939	.09
20	1541.	12.8	41.63	2.4	2 1941	.03
21	1601.	13.3	43.75	2.3	9 1952	-.02
22	1677.	13.9	45.86	2.2	10 1938	-.07
23	1722.	14.3	47.97	2.1	2 1939	-.12
24	1737.	14.4	50.09	2.0	10 1937	-.17

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	1465.	8.1	1.47	68.1	10 1936	2.83
2	1469.	8.1	3.59	27.9	2 1935	2.13
3	1503.	8.3	5.70	17.5	11 1935	1.76
4	1518.	8.4	7.82	12.8	9 1939	1.51
5	1579.	8.7	9.94	10.1	9 1931	1.31
6	1579.	8.7	12.06	8.3	9 1940	1.15
7	1586.	8.8	14.18	7.1	10 1932	1.01
8	1586.	8.8	16.29	6.1	10 1934	.90
9	1590.	8.8	18.41	5.4	2 1937	.79
10	1595.	8.8	20.53	4.9	3 1940	.70
11	1760.	9.7	22.65	4.4	9 1961	.61
12	1767.	9.8	24.76	4.0	10 1933	.53
13	2122.	11.7	26.88	3.7	9 1938	.46
14	2243.	12.4	29.00	3.4	9 1937	.39
15	2556.	14.1	31.12	3.2	2 1939	.32
16	2556.	14.1	33.23	3.0	2 1941	.26
17	2605.	14.4	35.35	2.8	9 1976	.20
18	2644.	14.6	37.47	2.7	1 1934	.14
19	2939.	16.2	39.59	2.5	12 1937	.08
20	2967.	16.4	41.71	2.4	9 1930	.03
21	3120.	17.2	43.82	2.3	12 1939	-.02
22	3639.	20.1	45.94	2.2	10 1959	-.07
23	3671.	20.3	48.06	2.1	1 1962	-.12
24	3845.	21.2	50.18	2.0	12 1931	-.17

(continued)

YEARS (RECORD) MONTHS 47 0

DURATION IN MONTHS 4

EFFECTIVE YEARS 46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2197.	9.1	1.47	67.9	11 1932	2.83
2	2228.	9.2	3.59	27.8	10 1936	2.13
3	2429.	10.1	5.71	17.5	3 1940	1.76
4	2469.	10.2	7.84	12.8	10 1939	1.50
5	2469.	10.2	9.96	10.0	10 1940	1.31
6	2750.	11.4	12.08	8.3	1 1935	1.15
7	2771.	11.5	14.20	7.0	10 1931	1.01
8	2921.	12.1	16.32	6.1	11 1933	.89
9	2940.	12.2	18.44	5.4	12 1935	.79
10	2972.	12.3	20.56	4.9	3 1937	.70
11	3013.	12.5	22.69	4.4	10 1938	.61
12	3073.	12.7	24.81	4.0	10 1937	.53
13	3891.	16.1	26.93	3.7	2 1941	.45
14	4012.	16.6	29.05	3.4	2 1939	.38
15	4044.	16.7	31.17	3.2	9 1961	.32
16	4703.	19.5	33.29	3.0	10 1930	.25
17	4793.	19.8	35.42	2.8	11 1959	.20
18	5191.	21.5	37.54	2.7	9 1934	.14
19	6925.	28.7	39.66	2.5	12 1963	.08
20	7157.	29.6	41.78	2.4	1 1962	.03
21	8808.	36.5	43.90	2.3	10 1967	-.02
22	9473.	39.2	46.02	2.2	10 1958	-.07
23	9533.	39.5	48.14	2.1	10 1960	-.12
24	10640.	44.1	50.27	2.0	3 1934	-.17

(continued)

1

YEARS (RECORD) MONTHS | DURATION IN MONTHS
47 | 0 | 6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	3808.	10.5	1.48	67.7	1 1935	2.83
2	4411.	12.2	3.61	27.7	1 1934	2.13
3	4532.	12.5	5.73	17.4	1 1940	1.76
4	4653.	12.8	7.86	12.7	1 1937	1.50
5	4820.	13.3	9.99	10.0	12 1940	1.31
6	5182.	14.3	12.12	8.2	12 1937	1.15
7	5303.	14.6	14.25	7.0	12 1938	1.01
8	5423.	15.0	16.38	6.1	12 1931	.89
9	8019.	22.1	18.51	5.4	12 1961	.79
10	8744.	24.1	20.64	4.8	12 1935	.69
11	8745.	24.1	22.77	4.4	11 1932	.61
12	10676.	29.5	24.90	4.0	12 1963	.53
13	11642.	32.1	27.02	3.7	12 1959	.45
14	17801.	49.1	29.15	3.4	11 1930	.38
15	20626.	56.9	31.28	3.2	10 1958	.31
16	23456.	64.8	33.41	3.0	7 1934	.25
17	24018.	66.3	35.54	2.8	12 1960	.19
18	24320.	67.1	37.67	2.7	12 1967	.13
19	27657.	76.4	39.80	2.5	3 1974	.08
20	27942.	77.1	41.93	2.4	12 1945	.03
21	28300.	78.1	44.06	2.3	6 1938	-.03
22	29527.	81.5	46.19	2.2	1 1953	-.08
23	29976.	82.8	48.31	2.1	7 1939	-.13
24	30599.	84.5	50.44	2.0	12 1974	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	6234.	11.5	1.48	67.3	3 1940	2.83
2	7320.	13.5	3.63	27.6	3 1937	2.17
3	8226.	15.1	5.77	17.3	3 1941	1.75
4	8584.	15.8	7.91	12.6	2 1935	1.50
5	10033.	18.5	10.05	10.0	2 1939	1.30
6	14988.	27.6	12.19	8.2	3 1934	1.14
7	15785.	29.0	14.33	7.0	1 1938	1.01
8	16388.	30.2	16.47	6.1	1 1962	.89
9	16449.	30.3	18.61	5.4	1 1932	.78
10	24237.	44.6	20.75	4.8	1 1936	.69
11	25130.	46.2	22.89	4.4	3 1964	.60
12	28885.	53.2	25.03	4.0	1 1933	.52
13	33401.	61.5	27.17	3.7	3 1960	.45
14	37748.	69.5	29.31	3.4	3 1959	.38
15	40702.	74.9	31.45	3.2	2 1931	.31
16	47770.	87.9	33.59	3.0	3 1974	.25
17	48917.	90.0	35.73	2.8	3 1975	.19
18	49098.	90.4	37.87	2.6	3 1961	.13
19	49461.	91.0	40.01	2.5	3 1968	.07
20	49883.	91.8	42.15	2.4	3 1948	.02
21	50004.	92.0	44.29	2.3	3 1956	-.03
22	50245.	92.5	46.43	2.2	3 1957	-.08
23	51936.	95.6	48.57	2.1	3 1946	-.13
24	54469.	100.2	50.71	2.0	4 1953	-.18

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	18811.	26.0	1.49	67.0	5 1937	2.82
2	20924.	28.9	3.64	27.4	2 1935	2.12
3	21166.	29.2	5.80	17.3	4 1940	1.75
4	25512.	35.2	7.95	12.6	2 1939	1.49
5	30584.	42.2	10.10	9.9	3 1962	1.30
6	43564.	60.1	12.25	8.2	3 1936	1.14
7	49058.	67.7	14.40	6.9	3 1932	1.00
8	50205.	69.3	16.56	6.0	12 1959	.88
9	57631.	79.5	18.71	5.3	6 1964	.78
10	62038.	85.6	20.86	4.8	4 1941	.68
11	66143.	91.3	23.01	4.3	2 1934	.60
12	68136.	94.0	25.16	4.0	7 1957	.52
13	75501.	104.2	27.32	3.7	12 1958	.44
14	91198.	125.9	29.47	3.4	6 1968	.37
15	92949.	128.3	31.62	3.2	4 1953	.30
16	94277.	130.1	33.77	3.0	3 1956	.24
17	96270.	132.9	35.92	2.8	3 1946	.18
18	96390.	133.0	38.07	2.6	6 1954	.12
19	102911.	142.0	40.23	2.5	3 1931	.07
20	103937.	143.5	42.38	2.4	4 1942	.01
21	110336.	152.3	44.53	2.2	3 1947	-.04
22	111484.	153.9	46.68	2.1	8 1944	-.09
23	120419.	166.2	48.83	2.0	3 1974	-.14
24	144387.	199.3	50.99	2.0	12 1960	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	48550.	33.5	1.53	65.5	3 1941	2.81
2	52534.	36.3	3.72	26.8	7 1938	2.10
3	55311.	38.2	5.92	16.9	5 1935	1.73
4	118884.	82.0	8.12	12.3	3 1960	1.47
5	127276.	87.8	10.32	9.7	2 1933	1.28
6	157945.	109.0	12.52	8.0	3 1965	1.12
7	178291.	123.0	14.72	6.8	3 1962	.98
8	195014.	134.6	16.92	5.9	3 1956	.86
9	206606.	142.6	19.12	5.2	3 1947	.76
10	258225.	178.2	21.32	4.7	3 1958	.66
11	269454.	186.0	23.52	4.3	3 1943	.58
12	300667.	207.5	25.72	3.9	5 1953	.50
13	310991.	214.6	27.92	3.6	3 1969	.42
14	388027.	267.8	30.12	3.3	3 1975	.35
15	393159.	271.3	32.31	3.1	3 1945	.28
16	436808.	301.5	34.51	2.9	6 1949	.22
17	443872.	306.3	36.71	2.7	9 1971	.16
18	670995.	463.1	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	110623.	38.2	1.60	62.7	5 1940	2.77
2	185063.	63.9	3.90	25.7	4 1936	2.06
3	297175.	102.5	6.20	16.1	3 1962	1.69
4	411703.	142.1	8.50	11.8	8 1957	1.44
5	552553.	190.7	10.80	9.3	3 1948	1.24
6	817953.	282.3	13.10	7.6	12 1966	1.08
7	942080.	325.1	15.40	6.5	3 1974	.94
8	976492.	337.0	17.70	5.7	5 1953	.83

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	256443.	44.2	1.76	56.9	3 1941	2.69
2	750415.	129.5	4.29	23.3	3 1962	1.99
3	1376483.	237.5	6.82	14.7	3 1949	1.62
4	1810202.	312.3	9.36	10.7	12 1970	1.36

INDEPENDENT EVENTS EXHAUSTED

Maple River at Mapleton - Year 1980 Case

(Same results as in year 2030 case. See table in Results of Year 2030 Partial Duration Analyses.)

Red River at Rustad - Year 1980 Case

RED RIVER AT RUSTAD

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2087.	17.3	1.47	68.2	10 1936	2.84
2	2147.	17.8	3.58	27.9	10 1934	2.13
3	2329.	19.3	5.69	17.6	10 1932	1.76
4	2642.	21.9	7.81	12.8	9 1976	1.51
5	2932.	24.3	9.92	10.1	10 1940	1.31
6	3171.	26.3	12.04	8.3	8 1932	1.15
7	3174.	26.3	14.15	7.1	10 1939	1.02
8	3295.	27.3	16.26	6.1	10 1933	.90
9	4014.	33.2	18.38	5.4	12 1936	.79
10	4016.	33.3	20.49	4.9	8 1936	.70
11	4137.	34.3	22.61	4.4	8 1934	.61
12	4140.	34.3	24.72	4.0	10 1931	.53
13	4195.	34.7	26.83	3.7	12 1970	.46
14	4919.	40.7	28.95	3.5	12 1934	.39
15	5057.	41.9	31.06	3.2	9 1930	.32
16	5287.	43.8	33.18	3.0	10 1935	.26
17	5764.	47.7	35.29	2.8	1 1933	.20
18	5825.	48.2	37.40	2.7	1 1936	.14
19	6127.	50.7	39.51	2.5	1 1938	.09
20	6247.	51.7	41.63	2.4	2 1937	.03
21	6309.	52.2	43.75	2.3	1 1940	-.02
22	6368.	52.7	45.86	2.2	12 1933	-.07
23	6549.	54.2	47.97	2.1	2 1935	-.12
24	6610.	54.7	50.09	2.0	2 1970	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	3400.	18.8	1.47	68.1	11 1936	2.83
2	3592.	19.8	3.59	27.9	10 1934	2.13
3	3773.	20.8	5.70	17.5	10 1932	1.76
4	5283.	29.2	7.82	12.8	10 1939	1.51
5	5343.	29.5	9.94	10.1	10 1940	1.31
6	6418.	35.4	12.06	8.3	11 1933	1.15
7	7801.	43.1	14.18	7.1	1 1935	1.01
8	7988.	44.1	16.29	6.1	11 1931	.90
9	8471.	46.8	18.41	5.4	11 1935	.79
10	8586.	47.4	20.53	4.9	1 1971	.70
11	8828.	48.7	22.65	4.4	1 1933	.61
12	8948.	49.4	24.76	4.0	2 1937	.53
13	9250.	51.1	26.88	3.7	2 1936	.46
14	9794.	54.1	29.00	3.4	2 1938	.39
15	9914.	54.7	31.12	3.2	2 1934	.32
16	9962.	55.0	33.23	3.0	8 1936	.26
17	9975.	55.1	35.35	2.8	1 1940	.20
18	10294.	56.8	37.47	2.7	10 1930	.14
19	12148.	67.1	39.59	2.5	1 1970	.08
20	12571.	69.4	41.71	2.4	1 1941	.03
21	12692.	70.1	43.82	2.3	2 1931	-.02
22	12881.	71.1	45.94	2.2	9 1976	-.07
23	12999.	71.8	48.06	2.1	11 1938	-.12
24	13356.	73.7	50.18	2.0	2 1932	-.17

(continued)

YEARS (RECORD) MONTHS 47 0   DURATION IN MONTHS 4

EFFECTIVE YEARS 46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4844.	20.1	1.47	67.9	11 1936	2.83
2	5499.	22.8	3.59	27.8	10 1932	2.13
3	5690.	23.6	5.71	17.5	11 1934	1.76
4	8950.	37.1	7.84	12.8	11 1939	1.50
5	9312.	38.6	9.96	10.0	11 1940	1.31
6	9663.	40.0	12.08	8.3	12 1937	1.15
7	11172.	46.3	14.20	7.0	12 1935	1.01
8	11414.	47.3	16.32	6.1	12 1931	.89
9	12133.	50.2	18.44	5.4	2 1933	.79
10	15772.	65.3	20.56	4.9	11 1930	.70
11	15815.	65.5	22.69	4.4	2 1939	.61
12	16117.	66.7	24.81	4.0	2 1970	.53
13	16787.	69.5	26.93	3.7	12 1938	.45
14	17023.	70.5	29.05	3.4	2 1971	.38
15	18170.	75.2	31.17	3.2	4 1934	.32
16	18532.	76.7	33.29	3.0	3 1937	.25
17	19921.	82.5	35.42	2.8	3 1940	.20
18	21913.	90.7	37.54	2.7	1 1930	.14
19	23548.	97.5	39.66	2.5	12 1961	.08
20	24992.	103.5	41.78	2.4	3 1931	.03
21	27165.	112.5	43.90	2.3	3 1935	-.02
22	27648.	114.5	46.02	2.2	1 1975	-.07
23	27830.	115.2	48.14	2.1	4 1932	-.12
24	28614.	118.5	50.27	2.0	2 1949	-.17

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	6

EFFECTIVE YEARS
16.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	10117.	27.9	1.48	67.7	12 1936	2.83
2	11203.	30.9	3.61	27.7	12 1934	2.13
3	11324.	31.3	5.73	17.4	12 1932	1.76
4	15257.	42.1	7.86	12.7	1 1940	1.50
5	16333.	45.1	9.99	10.0	2 1934	1.31
6	17721.	48.9	12.12	8.2	2 1936	1.15
7	17914.	49.5	14.25	7.0	1 1941	1.01
8	19544.	54.0	16.38	6.1	1 1932	.89
9	23408.	64.6	18.51	5.4	1 1931	.79
10	26970.	74.5	20.64	4.8	1 1939	.69
11	30460.	84.1	22.77	4.4	2 1970	.61
12	32573.	89.9	24.90	4.0	2 1938	.53
13	37173.	102.6	27.02	3.7	1 1962	.45
14	44527.	122.9	29.15	3.4	2 1971	.38
15	45493.	125.6	31.28	3.2	2 1957	.31
16	46833.	129.3	33.41	3.0	1 1942	.25
17	48934.	135.1	35.54	2.8	2 1949	.19
18	52255.	144.3	37.67	2.7	2 1950	.13
19	53346.	147.3	39.80	2.5	6 1937	.08
20	56063.	154.8	41.93	2.4	6 1933	.03
21	61250.	169.1	44.06	2.3	2 1968	-.03
22	62333.	172.1	46.19	2.2	2 1931	-.08
23	63001.	173.9	48.31	2.1	2 1961	-.13
24	63720.	175.9	50.44	2.0	3 1975	-.17

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	21646.	39.8	1.48	67.3	2 1933	2.83
2	22189.	40.8	3.63	27.6	2 1935	2.12
3	22310.	41.1	5.77	17.3	2 1937	1.75
4	30581.	56.3	7.91	12.6	2 1934	1.50
5	38816.	71.4	10.05	10.0	4 1940	1.30
6	43103.	79.3	12.19	8.2	4 1932	1.14
7	45931.	84.5	14.33	7.0	3 1941	1.01
8	46354.	85.3	16.47	6.1	3 1936	.89
9	46785.	86.1	18.61	5.4	4 1931	.78
10	59524.	109.5	20.75	4.8	4 1938	.69
11	70790.	130.3	22.89	4.4	2 1939	.60
12	73763.	135.8	25.03	4.0	3 1962	.52
13	83915.	154.4	27.17	3.7	4 1942	.45
14	89831.	165.3	29.31	3.4	4 1970	.38
15	96584.	177.8	31.45	3.2	3 1949	.31
16	97921.	180.2	33.59	3.0	4 1961	.25
17	104795.	192.9	35.73	2.8	3 1957	.19
18	110312.	203.0	37.87	2.6	5 1971	.13
19	112109.	206.3	40.01	2.5	4 1968	.07
20	118198.	217.5	42.15	2.4	3 1965	.02
21	120984.	222.7	44.29	2.3	4 1959	-.03
22	126831.	233.4	46.43	2.2	3 1964	-.08
23	132575.	244.0	48.57	2.1	4 1955	-.13
24	141866.	261.1	50.71	2.0	6 1930	-.18

1

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   12

EFFECTIVE YEARS
46.00

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL F
1	44747.	61.8	1.49	67.0	1 1935	2.82
2	48189.	66.5	3.64	27.4	2 1933	2.12
3	54226.	74.8	5.80	17.3	5 1937	1.72
4	81696.	112.8	7.95	12.6	12 1931	1.49
5	87431.	120.7	10.10	9.9	5 1940	1.30
6	89665.	123.8	12.25	8.2	3 1936	1.14
7	103369.	142.7	14.40	6.9	11 1938	1.00
8	113029.	156.0	16.56	6.0	5 1941	.88
9	125889.	173.8	18.71	5.3	3 1962	.78
10	151789.	209.5	20.86	4.8	12 1930	.68
11	162475.	224.3	23.01	4.3	6 1949	.60
12	172376.	237.9	25.16	4.0	4 1959	.52
13	185658.	256.3	27.32	3.7	5 1942	.44
14	197732.	272.9	29.47	3.4	6 1971	.37
15	200449.	276.7	31.62	3.2	9 1976	.30
16	206728.	285.3	33.77	3.0	7 1955	.24
17	208901.	288.3	35.92	2.8	8 1968	.18
18	215603.	297.6	38.07	2.6	6 1970	.12
19	223149.	308.0	40.23	2.5	4 1957	.07
20	233353.	322.1	42.38	2.4	10 1964	.01
21	251947.	347.8	44.53	2.2	4 1960	-.04
22	268007.	369.9	46.68	2.1	9 1973	-.09
23	289681.	399.8	48.83	2.0	6 1946	-.14
24	320290.	442.1	50.99	2.0	10 1963	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	115576.	79.8	1.53	65.5	4 1939	2.81
2	153550.	106.0	3.72	26.8	5 1937	2.10
3	193517.	133.6	5.92	16.9	4 1932	1.73
4	199313.	137.6	8.12	12.3	3 1941	1.47
5	384175.	265.1	10.32	9.7	3 1962	1.28
6	407358.	281.1	12.52	8.0	3 1960	1.12
7	413335.	285.3	14.72	6.8	6 1971	.98
8	480108.	331.3	16.92	5.9	1 1950	.86
9	481617.	332.4	19.12	5.2	2 1957	.76
10	519230.	358.3	21.32	4.7	3 1965	.66
11	554970.	383.0	23.52	4.3	3 1943	.58
12	616913.	425.8	25.72	3.9	9 1976	.50
13	624097.	430.7	27.92	3.6	3 1969	.42
14	703126.	485.3	30.12	3.3	9 1974	.35
15	748949.	516.9	32.31	3.1	3 1947	.28
16	803345.	554.4	34.51	2.9	2 1955	.22
17	982049.	677.8	36.71	2.7	1 1952	.16
18	1160632.	801.0	38.91	2.6	3 1945	.10
19	1321164.	911.8	41.11	2.4	3 1967	.05

INDEPENDENT EVENTS EXHAUSTED

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	249324.	86.0	1.60	62.7	2 1935	2.77
2	381178.	131.5	3.90	25.7	2 1939	2.06
3	749755.	258.7	6.20	16.1	2 1943	1.69
4	791533.	273.1	8.50	11.8	3 1962	1.44
5	1173030.	404.8	10.80	9.3	3 1958	1.24
6	1288886.	444.8	13.10	7.6	7 1971	1.08
7	1320039.	455.5	15.40	6.5	9 1976	.94
8	1384577.	477.8	17.70	5.7	7 1951	.83
9	1788594.	617.2	20.00	5.0	10 1966	.72
10	1879032.	648.4	22.30	4.5	6 1947	.62

INDEPENDENT EVENTS EXHAUSTED

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	616193.	106.3	1.76	56.9	6 1938	2.69
2	1964564.	339.0	4.29	23.3	3 1962	1.99
3	2438492.	420.7	6.82	14.7	6 1946	1.62
4	2999357.	517.5	9.36	10.7	6 1975	1.36

INDEPENDENT EVENTS EXHAUSTED

Red River at Briarwood - Year 1980 Case

RED RIVER AT BRIARWOOD

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL
1	2162.	17.9	1.47	68.2	10 1936	2.84
2	2162.	17.9	3.58	27.9	10 1934	2.13
3	2283.	18.9	5.69	17.6	10 1932	1.76
4	2635.	21.8	7.81	12.8	9 1976	1.51
5	2886.	23.9	9.92	10.1	10 1940	1.31
6	3164.	26.2	12.04	8.3	8 1932	1.15
7	3188.	26.4	14.15	7.1	10 1939	1.02
8	3309.	27.4	16.26	6.1	10 1933	.90
9	4006.	33.2	18.38	5.4	12 1936	.79
10	4009.	33.2	20.49	4.9	8 1936	.70
11	4130.	34.2	22.61	4.4	8 1934	.61
12	4197	34.7	24.72	4.0	12 1970	.53
13	4758.	39.4	26.83	3.7	10 1931	.46
14	4852.	40.2	28.95	3.5	12 1934	.39
15	5050.	41.8	31.06	3.2	9 1930	.32
16	5362.	44.4	33.18	3.0	10 1935	.26
17	5455.	45.2	35.29	2.8	1 1933	.20
18	5697.	47.2	37.40	2.7	12 1935	.14
19	5878.	48.7	39.52	2.5	1 1938	.09
20	5938.	49.2	41.63	2.4	2 1937	.03
21	5999.	49.7	43.75	2.3	2 1935	-.02
22	6059.	50.2	45.86	2.2	1 1940	-.07
23	6180.	51.2	47.97	2.1	12 1933	-.12
24	6663.	55.2	50.09	2.0	2 1936	-.17

(continued)

1

YEARS (RECORD) MONTHS 47 0

DURATION IN MONTHS 3

EFFECTIVE YEARS 46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	3410.	18.8	1.47	68.1	11 1936	2.83
2	3603.	19.9	3.59	27.9	10 1934	2.13
3	3724.	20.6	5.70	17.5	10 1932	1.76
4	5294.	29.2	7.82	12.8	10 1940	1.51
5	5294.	29.2	9.94	10.1	10 1939	1.31
6	6248.	34.5	12.06	8.3	11 1933	1.15
7	7489.	41.3	14.18	7.1	1 1935	1.01
8	8361.	46.2	16.29	6.1	11 1935	.90
9	8515.	47.0	18.41	5.4	1 1933	.79
10	8575.	47.3	20.53	4.9	1 1971	.70
11	8614.	47.6	22.65	4.4	10 1931	.61
12	8696.	48.0	24.76	4.0	2 1937	.53
13	9360.	51.7	26.88	3.7	2 1936	.46
14	9541.	52.7	29.00	3.4	2 1938	.39
15	9662.	53.3	31.12	3.2	1 1940	.32
16	9973.	55.1	33.23	3.0	8 1936	.26
17	10304.	56.9	35.35	2.8	10 1930	.20
18	10447.	57.7	37.47	2.7	2 1934	.14
19	12319.	68.0	39.59	2.5	1 1970	.08
20	12620.	69.7	41.71	2.4	1 1932	.03
21	12681.	70.0	43.82	2.3	2 1931	-.02
22	12870.	71.1	45.94	2.2	9 1976	-.07
23	12889.	71.2	48.06	2.1	11 1939	-.12
24	14320.	79.1	50.18	2.0	8 1933	-.17

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4852.	20.1	1.47	67.9	11 1936	2.83
2	5446.	22.6	3.59	27.8	10 1932	2.13
3	5636.	23.3	5.71	17.5	11 1934	1.76
4	8897.	36.8	7.84	12.8	11 1939	1.50
5	9489.	39.3	9.96	10.0	12 1933	1.31
6	10044.	41.6	12.08	8.3	11 1940	1.15
7	11059.	45.8	14.20	7.0	12 1935	1.01
8	11575.	47.9	16.32	6.1	2 1933	.89
9	12749.	52.8	18.44	5.4	12 1931	.79
10	15598.	64.6	20.56	4.9	11 1930	.70
11	15620.	64.7	22.69	4.4	2 1938	.61
12	16344.	67.7	24.81	4.0	2 1970	.53
13	16673.	69.0	26.93	3.7	12 1938	.45
14	17008.	70.4	29.05	3.4	2 1971	.38
15	17310.	71.7	31.17	3.2	4 1934	.32
16	17612.	72.9	33.29	3.0	3 1937	.25
17	19363.	80.2	35.42	2.8	3 1940	.20
18	22947.	95.0	37.54	2.7	1 1930	.14
19	23918.	99.0	39.66	2.5	12 1961	.08
20	27233.	112.8	41.78	2.4	1 1975	.03
21	27936.	115.7	43.90	2.3	3 1931	-.02
22	29218.	121.0	46.02	2.2	9 1976	-.07
23	29988.	124.2	48.14	2.1	2 1949	-.12
24	30713.	127.2	50.27	2.0	4 1932	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	10177.	28.1	1.48	67.7	12 1936	2.83
2	11092.	30.6	3.61	27.7	1 1935	2.13
3	11264.	31.1	5.73	17.4	12 1932	1.76
4	14956.	41.3	7.86	12.7	1 1940	1.50
5	16344.	45.1	9.99	10.0	1 1934	1.31
6	17721.	48.9	12.12	8.2	2 1936	1.15
7	19906.	55.0	14.25	7.0	1 1941	1.01
8	21234.	58.6	16.38	6.1	1 1932	.89
9	23227.	64.1	18.51	5.4	1 1931	.79
10	29264.	80.8	20.64	4.8	1 1939	.69
11	30883.	85.3	22.77	4.4	2 1970	.61
12	32388.	89.4	24.90	4.0	7 1934	.53
13	32875.	90.8	27.02	3.7	2 1938	.45
14	37716.	104.1	29.15	3.4	1 1962	.38
15	44527.	122.9	31.28	3.2	2 1971	.31
16	46036.	127.1	33.41	3.0	2 1957	.25
17	49368.	136.3	35.54	2.8	1 1942	.19
18	51530.	142.3	37.67	2.7	2 1949	.13
19	54126.	149.4	39.80	2.5	2 1950	.08
20	54674.	150.9	41.93	2.4	6 1933	.03
21	62277.	171.9	44.06	2.3	2 1961	-.03
22	62337.	172.1	46.19	2.2	2 1968	-.08
23	63297.	174.7	48.31	2.1	3 1975	-.13
24	67102.	185.2	50.44	2.0	7 1931	-.17

1

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	21174.	39.0	1.48	67.3	2 1933	2.83
2	21657.	39.9	3.63	27.6	2 1935	2.12
3	22080.	40.6	5.77	17.3	2 1937	1.75
4	30353.	55.9	7.91	12.6	4 1934	1.50
5	39340.	72.4	10.05	10.0	3 1940	1.30
6	47318.	87.1	12.19	8.2	4 1932	1.14
7	49006.	90.2	14.33	7.0	2 1936	1.01
8	50457.	92.9	16.47	6.1	4 1931	.89
9	55768.	102.6	18.61	5.4	2 1941	.78
10	65913.	121.3	20.75	4.8	4 1938	.69
11	72726.	133.8	22.89	4.4	3 1962	.60
12	74725.	137.5	25.03	4.0	2 1939	.52
13	86551.	159.3	27.17	3.7	3 1942	.45
14	98867.	182.0	29.31	3.4	3 1949	.38
15	109321.	201.2	31.45	3.2	4 1961	.31
16	111425.	205.1	33.59	3.0	3 1970	.25
17	112029.	206.2	35.73	2.8	3 1957	.19
18	128450.	236.1	37.87	2.6	3 1965	.13
19	128882.	237.2	40.01	2.5	4 1959	.07
20	130814.	240.8	42.15	2.4	4 1968	.02
21	131552.	242.1	44.29	2.3	5 1971	-.03
22	137385.	252.8	46.43	2.2	3 1964	-.08
23	154978.	285.2	48.57	2.1	6 1930	-.13
24	155799.	286.7	50.71	2.0	3 1960	-.18

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	42936.	59.3	1.49	67.0	2 1935	2.82
2	47887.	66.1	3.64	27.4	3 1933	2.12
3	69681.	96.2	5.80	17.3	3 1937	1.75
4	87371.	120.6	7.95	12.6	12 1931	1.49
5	97332.	134.3	10.10	9.9	3 1936	1.30
6	97755.	134.9	12.25	8.2	7 1940	1.14
7	115384.	159.3	14.40	6.9	11 1938	1.00
8	131865.	182.0	16.56	6.0	3 1962	.88
9	152332.	210.3	18.71	5.3	7 1941	.78
10	164467.	227.0	20.86	4.8	12 1930	.68
11	183847.	253.8	23.01	4.3	6 1949	.60
12	216569.	298.9	25.16	4.0	6 1971	.52
13	221580.	305.8	27.32	3.7	5 1959	.44
14	239209.	330.2	29.47	3.4	9 1976	.37
15	239390.	330.4	31.62	3.2	8 1968	.30
16	254302.	351.0	33.77	3.0	7 1955	.24
17	261184.	360.5	35.92	2.8	4 1957	.19
18	286541.	395.5	38.07	2.6	9 1973	.12
19	298918.	412.6	40.23	2.5	6 1970	.07
20	303144.	418.4	42.38	2.4	10 1964	.01
21	323489.	446.5	44.53	2.2	2 1961	-.04
22	348967.	481.7	46.68	2.1	7 1942	-.09
23	369554.	510.1	48.83	2.0	6 1946	-.14
24	392798.	542.2	50.99	2.0	3 1975	-.19

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	113463.	78.3	1.53	65.5	4 1934	2.81
2	167013.	115.3	3.72	26.8	3 1937	2.10
3	205652.	141.9	5.92	16.9	4 1932	1.73
4	234088.	161.6	8.12	12.3	5 1941	1.47
5	295789.	204.1	10.32	9.7	3 1939	1.28
6	459943.	317.4	12.52	8.0	3 1962	1.12
7	493088.	340.3	14.72	6.8	3 1960	.98
8	515486.	355.8	16.92	5.9	6 1971	.86
9	567468.	391.6	19.12	5.2	1 1950	.76
10	585459.	404.1	21.32	4.7	2 1957	.66
11	689361.	475.8	23.52	4.3	3 1965	.58
12	697149.	481.1	25.72	3.9	3 1975	.50
13	858888.	592.8	27.92	3.6	3 1969	.42
14	914431.	631.1	30.12	3.3	3 1947	.35
15	1059628.	731.3	32.31	3.1	2 1955	.28
16	1195407.	825.0	34.51	2.9	5 1943	.22
17	1384375.	955.4	36.71	2.7	1 1952	.16
18	1892172.	1305.9	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	255663.	88.2	1.60	62.7	2 1935	2.77
2	441793.	152.5	3.90	25.7	2 1939	2.06
3	936670.	323.2	6.20	16.1	3 1943	1.69
4	953031.	328.9	8.50	11.8	3 1962	1.44
5	1412591.	487.5	10.80	9.3	3 1958	1.24
6	1661267.	573.3	13.10	7.6	3 1950	1.08
7	1668814.	575.9	15.40	6.5	8 1973	.94
8	2506066.	864.8	17.70	5.7	10 1966	.83
9	3125010.	1078.4	20.00	5.0	3 1954	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	679585.	117.3	1.76	56.9	6 1938	2.69
2	2365622.	408.2	4.29	23.3	3 1962	1.99
3	3604476.	621.9	6.82	14.7	6 1946	1.62
4	4211043.	726.6	9.36	10.7	3 1975	1.36

INDEPENDENT EVENTS EXHAUSTED

Red River at Fargo - Year 1980 Case

RED RIVER AT FARGO/MOORHEAD

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	3724.	30.8	1.47	68.2	11 1936	2.84
2	4186.	34.7	3.58	27.9	12 1970	2.13
3	4332.	35.9	5.69	17.6	10 1940	1.7[illegible]
4	4509.	37.3	7.81	12.8	11 1934	1.51
5	4634.	38.4	9.92	10.1	10 1939	1.31
6	4755.	39.4	12.04	8.3	10 1933	1.15
7	4897.	40.6	14.15	7.1	9 1930	1.02
8	5238.	43.4	16.26	6.1	10 1932	.90
9	5299.	43.9	18.38	5.4	10 1935	.79
10	5302.	43.9	20.49	4.9	8 1936	.70
11	5423.	44.9	22.61	4.4	8 1934	.61
12	5450.	45.1	24.72	4.0	1 1935	.53
13	5450.	45.1	26.83	3.7	1 1933	.46
14	5501.	45.6	28.95	3.5	9 1976	.39
15	5632.	46.6	31.06	3.2	1 1937	.32
16	5695.	47.2	33.18	3.0	12 1935	.26
17	5873.	48.6	35.29	2.8	1 1939	.20
18	5966.	49.4	37.40	2.7	8 1932	.14
19	6054.	50.1	39.52	2.5	1 1940	.09
20	6178.	51.2	41.63	2.4	12 1937	.03
21	6204.	51.4	43.75	2.3	10 1931	-.02
22	6658.	55.1	45.86	2.2	2 1936	-.07
23	6718.	55.6	47.97	2.1	2 1970	-.12
24	7201.	59.6	50.09	2.0	2 1934	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
17   0   3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	6366.	35.1	1.47	68.1	11 1936	2.83
2	6648.	36.7	3.59	27.9	10 1939	2.13
3	6648.	36.7	5.70	17.5	10 1940	1.76
4	7151.	39.5	7.82	12.8	11 1934	1.51
5	7695.	42.5	9.94	10.1	11 1933	1.31
6	8097.	44.7	12.06	8.3	10 1932	1.15
7	8298.	45.8	14.18	7.1	11 1935	1.01
8	8508.	47.0	16.29	6.1	2 1933	.90
9	8571.	47.3	18.41	5.4	1 1971	.79
10	8689.	48.0	20.53	4.9	2 1937	.70
11	8810.	48.6	22.65	4.4	2 1935	.61
12	9353.	51.6	24.76	4.0	2 1936	.53
13	9534.	52.6	26.88	3.7	2 1938	.46
14	9658.	53.3	29.00	3.4	1 1940	.39
15	9908.	54.7	31.12	3.2	8 1934	.32
16	9968.	55.0	33.23	3.0	10 1931	.26
17	~~10149.~~	~~56.0~~	~~35.35~~	~~2.8~~	~~10 1930~~	~~.20~~
18	10440.	57.6	37.47	2.7	2 1934	.14
19	11236.	62.0	39.59	2.5	8 1936	.08
20	~~12314.~~	~~68.0~~	~~41.71~~	~~2.4~~	~~1 1970~~	~~.03~~
21	12616.	69.7	43.82	2.3	1 1932	-.02
22	12674.	70.0	45.94	2.2	2 1931	-.07
23	12826.	70.8	48.06	2.1	11 1939	-.12
24	14074.	77.7	50.18	2.0	8 1932	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	9122.	37.8	1.47	67.9	12 1936	2.83
2	9960.	41.2	3.59	27.8	1 1975	2.13
3	10251.	42.4	5.71	17.5	11 1979	1.76
4	10933.	45.3	7.84	12.8	12 1933	1.50
5	10993.–	45.5	9.96	10.0	12 1935	1.31
6	11054.	45.8	12.08	8.3	12 1932	1.15
7	11398.	47.2	14.20	7.0	11 1940	1.01
8	12550.	52.0	16,32	6.1	9 1934	.89
9	14193.	58.8	18.44	5.4	12 1931	.79
10	15443.	63.9	20.56	4.9	11 1930	.70
11	15613.	64.7	22.69	4.4	2 1938	.61
12	16338.	67.7	24.81	4.0	2 1970	.53
13	16608.	68.8	26.93	3.7	12 1938	.45
14	17002.	70.4	29.05	3.4	2 1971	.38
15	17304.	71.7	31.17	3.2	1 1934	.32
16	18955.	78.5	33.29	3.0	8 1932	.25
17	19353.	80.1	35.42	2.8	3 1940	.20
18	22940.	95.0	37.54	2.7	1 1930	.14
19	23853.	98.8	39.66	2.5	12 1961	.08
20	25997.	107.7	41.78	2.4	4 1933	.03
21	27226.	112.7	43.90	2.3	1 1975	-.02
22	27926.	115.6	46.02	2.2	3 1931	-.07
23	29982.	124.2	48.14	2.1	2 1949	-.12
24	30706.	127.2	50.27	2.0	4 1932	-.17

(continued)

1

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   6

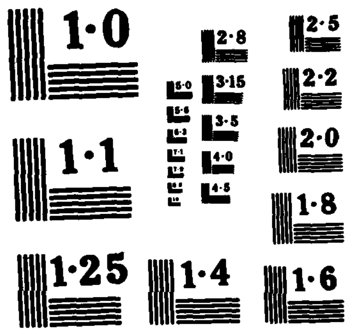
EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL T
1	14424.	39.8	1.48	67.7	12 193[illegible]	2.83
2	15390.	42.5	3.61	[illegible]	12 1934	2.1[illegible]
3	16306.	45.0	5.73	17.4	1 19[illegible]	1.7[illegible]
4	16607.	45.8	7.86	12.[illegible]	1 1933	1.5[illegible]
5	17651.	48.7	9.99	10.[illegible]	[illegible] 193[illegible]	1.31
6	17694.	48.8	12.12	8.[illegible]	1 1934	1.15
7	21256.	58.7	14.25	7.[illegible]	1 1941	1.01
8	22584.	62.3	16.38	6.1	1 193[illegible]	.89
9	23067.	63.7	18.51	5.4	1 1931	.79
10	29105.	80.3	20.64	4.8	1 1939	.69
11	30813.	85.1	22.77	4.4	2 197[illegible]	.61
12	32805.	90.6	24.90	[illegible]	2 193[illegible]	.5[illegible]
13	37557.	103.7	27.02	3.7	1 196[illegible]	.45
14	42176.	116.4	29.15	3.4	[illegible] 193[illegible]	.3[illegible]
15	44457.	122.7	31.28	3.2	2 1971	.31
16	45966.	126.9	33.41	3.0	2 195[illegible]	.25
17	49209.	135.8	35.54	2.9	1 1943	.19
18	51460.	142.1	37.67	2.[illegible]	2 19[illegible]	.1[illegible]
19	54056.	149.2	39.80	2.5	2 19[illegible]	.0[illegible]
20	55941.	154.[illegible]	41.93	2.4	[illegible]	[illegible]
21	62207.	171.7	44.0[illegible]	2.3	1 1961	-.03
22	62267.	171.9	46.1[illegible]	[illegible]	[illegible]	-.0[illegible]
23	63286.	174.7	48.[illegible]	[illegible]	2 197[illegible]	-.13
24	66929.	184.8	5[illegible]	[illegible]	[illegible]	-.1[illegible]

AD-A157 283 FARGO-MOORHEAD URBAN STUDY WATER SUPPLY APPENDIX VOLUME 5/5
1 PHASE 1 PART 1..(U) CORPS OF ENGINEERS ST PAUL MN ST
PAUL DISTRICT MAY 85

UNCLASSIFIED F/G 13/2 NL

END
FILMED
DTIC



NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	25869.	47.6	1.48	67.3	2 1935	2.83
2	26291.	48.4	3.63	27.6	2 1937	2.12
3	26895.	49.5	5.77	17.3	2 1933	1.75
4	31699.	58.3	7.91	12.6	4 1934	1.50
5	40560.	74.6	10.05	10.0	3 1940	1.30
6	48650.	89.5	12.19	8.2	3 1932	1.14
7	48690.	89.6	14.33	7.0	2 1936	1.01
8	50294.	92.6	16.47	6.1	4 1931	.89
9	56961.	104.8	18.61	5.4	2 1941	.78
10	65749.	121.0	20.75	4.8	4 1938	.69
11	72437.	133.3	22.89	4.4	3 1962	.60
12	74409.	136.9	25.03	4.0	2 1939	.52
13	86263.	158.8	27.17	3.7	3 1942	.45
14	98579.	181.4	29.31	3.4	3 1949	.38
15	109157.	200.9	31.45	3.2	4 1961	.31
16	111136.	204.5	33.59	3.0	3 1970	.25
17	111740.	205.6	35.73	2.8	3 1957	.19
18	128162.	235.9	37.87	2.6	3 1965	.13
19	128718.	236.9	40.01	2.5	4 1959	.07
20	130650.	240.4	42.15	2.4	4 1968	.02
21	131466.	242.0	44.29	2.3	5 1971	-.03
22	137097.	252.3	46.43	2.2	3 1964	-.08
23	154923.	285.1	48.57	2.1	6 1930	-.13
24	155511.	286.2	50.71	2.0	3 1960	-.18

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL
1	47131.	65.1	1.49	67.0	2 1935	2.82
2	53591.	74.0	3.64	27.4	3 1933	[illegible]
3	73877.	102.0	5.80	17.3	3 1937	[illegible]
4	88547.	122.2	7.95	12.6	12 1931	1.47
5	96999.	133.9	10.10	9.9	3 1936	1.30
6	98931.	136.6	12.25	8.2	7 1940	1.14
7	115051.	158.8	14.40	6.9	11 1938	1.00
8	131533.	181.6	16.56	6.0	3 1962	.88
9	153509.	211.9	18.71	5.3	7 1941	.78
10	164134.	226.6	20.86	4.8	12 1930	.68
11	183514.	253.3	23.01	4.3	6 1949	.60
12	216236.	298.5	25.16	4.0	6 1971	.52
13	221247.	305.4	27.32	3.7	5 1959	.44
14	239057.	330.0	29.47	3.4	8 1968	.37
15	241895.	333.9	31.62	3.2	9 1976	.30
16	253969.	350.6	33.77	3.0	7 1955	.24
17	260852.	360.1	35.92	2.8	4 1957	.18
18	286208.	395.1	38.07	2.6	9 1973	.12
19	298585.	412.1	40.23	2.5	6 1970	.07
20	302811.	418.0	42.38	2.4	10 1964	.01
21	323157.	446.1	44.53	2.2	2 1961	-.04
22	348634.	481.2	46.68	2.1	7 1942	-.09
23	369221.	509.6	48.83	2.0	6 1946	.14
24	392465.	541.7	50.99	2.0	3 1975	-.19

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	120344.	83.1	1.53	65.5	4 1934	2.81
2	170876.	117.9	3.72	26.2	3 1937	2.10
3	206496.	142.5	5.92	16.9	4 1932	[illegible]
4	236441.	163.2	8.12	12.3	5 1941	1.4[illegible]
5	295124.	203.7	10.32	9.7	3 1939	1.28
6	459278.	317.0	12.52	8.0	3 1962	1.12
7	492423.	339.8	14.72	6.8	3 1960	.98
8	514821.	355.3	16.92	5.9	6 1971	.86
9	566802.	391.2	19.12	5.2	1 1950	.76
10	584793.	403.6	21.32	4.7	2 1957	.66
11	688695.	475.3	23.52	4.3	3 1965	.58
12	696483.	480.7	25.72	3.9	3 1975	.50
13	858223.	592.3	27.92	3.6	3 1969	.42
14	913766.	630.6	30.12	3.3	3 1947	.35
15	1058963.	730.8	32.31	3.1	2 1955	.28
16	1194742.	824.6	34.51	2.9	5 1943	.22
17	1383709.	955.0	36.71	2.7	1 1952	.16
18	1891507.	1305.4	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	267916.	92.5	1.60	62.7	2 1935	2.77
2	444990.	153.6	3.90	25.7	2 1939	2.04
3	938358.	323.8	6.20	16.1	3 194[illegible]	1.6[illegible]
4	951701.	328.4	8.50	11.8	3 1962	1.4[illegible]
5	1411260.	487.0	10.80	9.3	3 1958	1.24
6	1659936.	572.8	13.10	7.6	3 1950	1.00
7	1667483.	575.4	15.40	6.5	8 1973	.94
8	2504736.	864.3	17.70	5.7	10 1966	.83
9	3123680.	1077.9	20.00	5.0	3 1954	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	695036.	119.9	1.76	56.9	6 1938	2.69
2	2362961.	407.7	4.29	23.3	3 1962	1.99
3	3604833.	622.0	6.82	14.7	6 1946	1.62
4	4208382.	726.1	9.36	10.7	3 19[illegible]	1.3[illegible]

INDEPENDENT EVENTS EXHAUSTED

1

READY.

Red River at North River - Year 1980 Case

YEAR 1980 NORTH RIVER/KRAGNES

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2259.	18.7	1.47	68.2	11 1936	2.84
2	2707.	22.4	3.58	27.9	8 1936	2.13
3	2756.	22.8	5.69	17.6	12 1970	1.76
4	2828.	23.4	7.81	12.8	8 1934	1.51
5	2854.	23.6	9.92	10.1	10 1940	1.31
6	2862.	23.7	12.04	8.3	9 1939	1.15
7	3044.	25.2	14.15	7.1	11 1934	1.02
8	3104.	25.7	16.26	6.1	9 1930	.90
9	3276.	27.1	18.38	5.4	10 1933	.79
10	3371.	27.9	20.49	4.9	8 1932	.70
11	3708.	30.7	22.61	4.4	9 1976	.61
12	3759.	31.1	24.72	4.0	10 1932	.53
13	3820.	31.6	26.83	3.7	10 1935	.46
14	4056.	33.6	28.95	3.5	1 1935	.39
15	4056.	33.6	31.06	3.2	1 1933	.32
16	4131.	34.2	33.18	3.0	11 1939	.26
17	~~4238.~~	~~35.1~~	~~35.29~~	~~2.8~~	~~1 1937~~	~~.20~~
18	4265.	35.3	37.40	2.7	12 1935	.14
19	4479.	37.1	39.52	2.5	1 1938	.09
20	~~4613.~~	~~38.2~~	~~41.63~~	~~2.4~~	~~9 1931~~	~~.03~~
21	4660.	38.6	43.75	2.3	1 1940	-.02
22	4748.	39.3	45.86	2.2	12 1933	-.07
23	4881.	40.4	47.97	2.1	9 1933	-.12
24	5146.	42.6	50.09	2.0	2 1936	-.17

1.

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	4128.	22.8	1.47	68.1	10 1939	2.83
2	4128.	22.8	3.59	27.9	10 1940	2.17
3	4149.	22.9	5.70	17.5	11 1976	1.76
4	4718.	26.0	7.82	12.8	9 1934	1.51
5	5169.	28.5	9.94	10.1	12 1934	1.31
6	5261.	29.0	12.06	8.3	9 1932	1.15
7	5477.	30.2	14.18	7.1	11 1933	1.01
8	6081.	33.6	16.29	6.1	11 1935	.90
9	6256.	34.5	18.41	5.4	12 1932	.79
10	6438.	35.5	20.53	4.9	1 1971	.70
11	6486.	35.8	22.65	4.4	2 1937	.61
12	7151.	39.5	24.76	4.0	2 1936	.53
13	7332.	40.5	26.88	3.7	2 1938	.46
14	7449.	41.1	29.00	3.4	10 1931	.39
15	7525.	41.5	31.12	3.2	1 1940	.32
16	7630.	42.1	33.23	3.0	10 1930	.26
17	7717.	42.6	35.35	2.8	8 1936	.20
18	8237.	45.5	37.47	2.7	2 1934	.14
19	10181.	56.2	39.59	2.5	1 1970	.08
20	10471.	57.8	41.71	2.4	2 1931	.03
21	10483.	57.9	43.82	2.3	1 1932	-.02
22	10555.	58.3	45.94	2.2	8 1933	-.07
23	10609.	58.6	48.06	2.1	11 1938	-.12
24	12264.	67.7	50.18	2.0	9 1976	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	5967.	24.7	1.47	67.9	11 1936	2.83
2	6467.	26.8	3.59	27.8	10 1934	2.13
3	6993.	29.0	5.71	17.5	11 1939	1.76
4	7131.	29.5	7.84	12.8	10 1932	1.50
5	7899.	32.7	9.96	10.0	11 1933	1.31
6	7902.	32.7	12.08	8.3	2 1935	1.15
7	8085.	33.5	14.20	7.0	12 1935	1.01
8	8140.	33.7	16.32	6.1	11 1940	.89
9	8627.	35.7	18.44	5.4	2 1933	.79
10	10978.	43.5	20.56	4.9	11 1931	.70
11	12185.	50.5	22.69	4.4	11 1930	.61
12	12672.	52.5	24.81	4.0	2 1938	.53
13	13396.	55.5	26.93	3.7	2 1970	.45
14	13700.	56.7	29.05	3.4	12 1938	.38
15	14060.	58.2	31.17	3.2	2 1971	.32
16	14215.	58.9	33.29	3.0	4 1934	.25
17	14729.	61.0	35.42	2.8	3 1937	.20
18	16479.	68.2	37.54	2.7	3 1940	.14
19	20081.	83.2	39.66	2.5	1 1930	.08
20	20945.	86.7	41.78	2.4	12 1961	.03
21	24367.	100.9	43.90	2.3	1 1975	-.02
22	25052.	103.7	46.02	2.2	3 1931	-.07
23	26139.	108.2	48.14	2.1	3 1932	-.12
24	27040.	112.0	50.27	2.0	2 1949	-.1[illegible]

(continued)

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	8921.	24.6	1.48	67.7	12 1936	2.83
2	9887.	27.3	3.61	27.7	12 1934	2.13
3	11517.	31.8	5.73	17.4	12 1932	1.76
4	11653.	32.2	7.86	12.7	1 1940	1.50
5	12905.	35.6	9.99	10.0	12 1933	1.31
6	13231.	36.5	12.12	8.2	2 1936	1.15
7	16604.	45.8	14.25	7.0	1 1941	1.01
8	17856.	49.3	16.38	6.1	12 1931	.89
9	18415.	50.8	18.51	5.4	1 1931	.79
10	24452.	67.5	20.64	4.8	1 1939	.69
11	26393.	72.9	22.77	4.4	2 1970	.61
12	27490.	75.9	24.90	4.0	6 1934	.53
13	28385.	78.4	27.02	3.7	2 1938	.45
14	32904.	90.8	29.15	3.4	1 1962	.38
15	38236.	105.6	31.28	3.2	6 1932	.31
16	40037.	110.5	33.41	3.0	2 1971	.25
17	41546.	114.7	35.54	2.8	2 1957	.19
18	44556.	123.0	37.67	2.7	1 1943	.13
19	47040.	129.9	39.80	2.5	2 1949	.08
20	49164.	135.7	41.93	2.4	6 1933	.03
21	49636.	137.0	44.06	2.3	2 1950	-.03
22	57787.	159.5	46.19	2.2	2 1961	-.08
23	57847.	159.7	48.31	2.1	2 1968	-.13
24	58947.	162.7	50.44	2.0	3 1975	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL
1	17930.	33.0	1.48	67.3	2 1939	2.83
2	18353.	33.8	3.63	27.6	2 1937	2.13
3	18957.	34.9	5.77	17.3	2 1933	1.75
4	24269.	44.7	7.91	12.6	2 1934	1.56
5	32874.	60.5	10.05	10.0	3 1946	1.30
6	40751.	75.0	12.19	8.2	2 1936	1.14
7	40964.	75.4	14.33	7.0	3 1932	1.01
8	43257.	79.6	16.47	6.1	4 1931	.89
9	49022.	90.2	18.61	5.4	2 1941	.78
10	58712.	108.1	20.75	4.8	4 1938	.69
11	64751.	119.2	22.89	4.4	3 1962	.60
12	66470	122.3	25.03	4.0	2 1939	.52
13	78577.	144.6	27.17	3.7	3 1942	.45
14	90893.	167.3	29.31	3.4	3 1949	.38
15	102120.	187.9	31.45	3.2	4 1961	.31
16	103450.	190.4	33.59	3.0	3 1970	.25
17	104054.	191.5	35.73	2.8	3 1957	.19
18	120476.	221.7	37.87	2.6	3 1965	.13
19	121681.	223.9	40.01	2.5	4 1959	.07
20	123613.	227.5	42.15	2.4	4 1968	.02
21	124022.	228.3	44.29	2.3	5 1971	-.03
22	129411.	238.2	46.43	2.2	3 1964	-.08
23	147051.	270.6	48.57	2.1	7 1930	-.13
24	147824.	272.1	50.71	2.0	3 1960	-.18

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	36169.	49.9	1.49	67.0	2 1935	2.82
2	42629.	58.8	3.64	27.4	3 1933	2.19
3	62914.	86.8	5.80	17.2	3 1937	1.75
4	77585.	107.1	7.95	12.6	12 1931	1.49
5	86037.	118.8	10.10	9.9	3 1936	1.30
6	87969.	121.4	12.25	8.2	7 1940	1.14
7	104088.	143.7	14.40	6.9	11 1938	1.00
8	120570.	166.4	16.56	6.0	3 1962	.89
9	142546.	196.8	18.71	5.3	7 1941	.78
10	153172.	211.4	20.86	4.8	12 1930	.69
11	172551.	238.2	23.01	4.3	6 1949	.60
12	205274.	283.3	25.16	4.0	6 1971	.52
13	210285.	290.3	27.32	3.7	5 1959	.44
14	228095.	314.8	29.47	3.4	8 1968	.37
15	230932.	318.8	31.62	3.2	9 1976	.31
16	243007.	335.4	33.77	3.0	7 1955	.24
17	249889.	344.9	35.92	2.8	4 1957	.18
18	275246.	379.9	38.07	2.6	9 1973	.12
19	287622.	397.0	40.23	2.5	6 1970	.07
20	291849.	402.8	42.38	2.4	10 1964	.01
21	312194.	430.9	44.53	2.2	2 1961	-.04
22	337672.	466.1	46.68	2.1	7 1942	-.09
23	358259.	494.5	48.83	2.0	6 1946	-.14
24	381502.	526.6	50.99	2.0	3 1975	-.19

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
17   0   24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	98419.	67.9	1.53	[illegible]	4 [illegible]	2.81
2	148951.	102.8	3.7[illegible]	[illegible]	[illegible]	2.10
3	184571.	127.4	5.92	16.9	4 1932	1.73
4	214516.	148.0	8.12	[illegible]	5 1941	1.4[illegible]
5	273199.	188.5	10.32	9.7	[illegible] 1939	1.28
6	437353.	301.8	12.52	[illegible]	[illegible] 1962	1.1[illegible]
7	470498.	324.7	14.72	6.8	3 1960	.98
8	492896.	340.2	16.92	5.9	6 1971	.86
9	544877.	376.0	19.12	5.2	1 1950	.76
10	562868.	388.5	21.32	4.7	2 1957	.66
11	666770.	460.2	23.52	4.3	3 1965	.58
12	674558.	465.5	25.72	[illegible]	[illegible]	.50
13	836298.	577.2	27.92	[illegible]	3 196[illegible]	.42
14	891841.	615.5	30.12	3.3	3 1947	.35
15	1037038.	715.7	32.31	3.1	2 1955	.28
16	1172817.	809.4	34.51	2.9	5 1943	.22
17	1361784.	939.8	36.71	2.7	1 1952	.16
18	1869582.	1290.3	38.91	2.6	3 1967	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	224066.	77.3	1.60	[illegible]	2 1935	2.77
2	401140.	138.4	3.90	[illegible]	9 1939	[illegible]
3	894508.	308.7	6.20	14.1	3 1943	1.69
4	907851.	313.3	8.50	11.8	3 1962	1.44
5	1367410.	471.9	10.80	9.3	3 1959	1.24
6	1616086.	557.7	13.10	7.6	2 1950	1.08
7	1623633.	560.3	15.40	6.5	8 1973	.94
8	2460886.	849.2	17.70	[illegible]	10 1966	.83
9	3079830.	1062.8	20.00	5.0	3 1954	.72

INDEPENDENT EVENTS EXHAUSTED

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	607335.	104.8	1.74	[illegible]	8 1938	2.69
2	2275260.	392.6	4.09	[illegible]	3 1962	1.99
3	3517133.	606.8	6.92	14.4	6 1944	[illegible]
4	4120682.	711.6	[illegible]	[illegible]	[illegible]	[illegible]

INDEPENDENT EVENTS EXHAUSTED

Buffalo River at Dilworth - Year 1980 Case

YEAR 1980 BUFFALO RIVER AT DILWORTH

YEARS (RECORD)	MONTHS	DURATION IN MONTHS
47	0	2

EFFECTIVE YEARS
46.92

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	60.	.5	1.47	68.2	9 1936	2.84
2	121.	1.0	3.58	27.9	2 1940	2.13
3	241.	2.0	5.69	17.6	2 1936	1.76
4	241.	2.0	7.81	12.8	9 1939	1.51
5	241.	2.0	9.92	10.1	2 1942	1.31
6	302.	2.5	12.04	8.3	8 1934	1.15
7	302.	2.5	14.15	7.1	9 1976	1.02
8	483.	4.0	16.26	6.1	3 1937	.90
9	543.	4.5	18.38	5.4	9 1932	.79
10	543.	4.5	20.49	4.9	2 1933	.70
11	543.	4.5	22.61	4.4	1 1938	.61
12	604.	5.0	24.72	4.0	2 1939	.53
13	724.	6.0	26.83	3.7	1 1937	.46
14	845.	7.0	28.95	3.5	9 1938	.39
15	906.	7.5	31.06	3.2	9 1939	.32
16	906.	7.5	33.18	3.0	9 1933	.26
17	906.	7.5	35.29	2.8	11 1936	.20
18	906.	7.5	37.40	2.7	10 1940	.14
19	966.	8.0	39.52	2.5	12 1932	.09
20	966.	8.0	41.63	2.4	12 1935	.03
21	966.	8.0	43.75	2.3	11 1939	-.02
22	966.	8.0	45.86	2.2	2 1950	-.07
23	966.	8.0	47.97	2.1	2 1963	-.12
24	1026.	8.5	50.09	2.0	8 1940	-.17

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 3

EFFECTIVE YEARS
46.83

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	181.	1.0	1.47	68.1	9 1936	2.83
2	241.	1.3	3.59	27.9	3 1940	2.13
3	543.	3.0	5.70	17.5	10 1939	1.76
4	604.	3.3	7.82	12.8	2 1936	1.51
5	664.	3.7	9.94	10.1	9 1934	1.31
6	845.	4.7	12.06	8.3	3 1937	1.15
7	845.	4.7	14.18	7.1	2 1938	1.01
8	906.	5.0	16.29	6.1	2 1933	.90
9	906.	5.0	18.41	5.4	2 1942	.79
10	906.	5.0	20.53	4.9	9 1976	.70
11	966.	5.3	22.65	4.4	9 1932	.61
12	1087.	6.0	24.76	4.0	2 1939	.53
13	1268.	7.0	26.88	3.7	12 1936	.46
14	1328.	7.3	29.00	3.4	10 1938	.39
15	1389.	7.7	31.12	3.2	9 1940	.32
16	1449.	8.0	33.23	3.0	9 1933	.26
17	1751.	9.7	35.35	2.8	2 1941	.20
18	1811.	10.0	37.47	2.7	2 1930	.14
19	1811.	10.0	39.59	2.5	9 1930	.08
20	1811.	10.0	41.71	2.4	2 1931	.03
21	1811.	10.0	43.82	2.3	1 1935	-.02
22	1932.	10.7	45.94	2.2	10 1931	-.07
23	2113.	11.7	48.06	2.1	2 1944	-.12
24	2113.	11.7	50.18	2.0	2 1949	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   4

EFFECTIVE YEARS
46.75

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	543.	2.3	1.47	67.9	10 1936	2.83
2	724.	3.0	3.59	27.8	3 1940	2.13
3	1026.	4.3	5.71	17.5	10 1939	1.76
4	1207.	5.0	7.84	12.8	2 1936	1.50
5	1207.	5.0	9.96	10.0	3 1937	1.31
6	1509.	6.3	12.08	8.3	2 1933	1.15
7	1509.	6.3	14.20	7.0	2 1938	1.01
8	1570.	6.5	16.32	6.1	9 1934	.89
9	1751.	7.3	18.44	5.4	10 1932	.79
10	1751.	7.3	20.56	4.9	2 1939	.70
11	1932.	8.0	22.69	4.4	10 1940	.61
12	2355.	9.8	24.81	4.0	10 1933	.53
13	2355.	9.8	26.93	3.7	10 1938	.45
14	2355.	9.8	29.05	3.4	2 1942	.38
15	2355.	9.8	31.17	3.2	9 1976	.32
16	2596.	10.8	33.29	3.0	2 1930	.25
17	2596.	10.8	35.42	2.8	11 1930	.20
18	2656.	11.0	37.54	2.7	2 1941	.14
19	2717.	11.3	39.66	2.5	2 1935	.08
20	2958.	12.3	41.78	2.4	10 1931	.03
21	3079.	12.8	43.90	2.3	3 1962	-.02
22	3200.	13.3	46.02	2.2	2 1949	-.07
23	3260.	13.5	48.14	2.1	2 1932	-.12
24	3441.	14.3	50.27	2.0	10 1937	-.17

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   6

EFFECTIVE YEARS
46.58

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	1449.	4.0	1.48	67.7	12 1936	2.83
2	1690.	4.7	3.61	27.7	2 1940	2.13
3	2596.	7.2	5.73	17.4	1 1933	1.76
4	2656.	7.3	7.86	12.7	2 1939	1.50
5	2777.	7.7	9.99	10.0	2 1936	1.31
6	3079.	8.5	12.12	8.2	12 1934	1.15
7	3079.	8.5	14.25	7.0	2 1938	1.01
8	3441.	9.5	16.38	6.1	12 1940	.89
9	3683.	10.2	18.51	5.4	1 1931	.79
10	4347.	12.0	20.64	4.8	12 1933	.69
11	4407.	12.2	22.77	4.4	2 1932	.61
12	4951.	13.7	24.90	4.0	2 1949	.53
13	5071.	14.0	27.02	3.7	2 1942	.45
14	5675.	15.7	29.15	3.4	2 1951	.38
15	5796.	16.0	31.28	3.2	2 1968	.31
16	5917.	16.3	33.41	3.0	1 1962	.25
17	6339.	17.5	35.54	2.8	1 1971	.19
18	6581.	18.2	37.67	2.7	2 1950	.13
19	7003.	19.3	39.80	2.5	4 1944	.08
20	7184.	19.8	41.93	2.4	2 1957	.03
21	7788.	21.5	44.06	2.3	2 1948	-.03
22	7969.	22.0	46.19	2.2	3 1930	-.08
23	7969.	22.0	48.31	2.1	3 1955	-.13
24	8090.	22.3	50.44	2.0	3 1965	-.17

(continued)

YEARS (RECORD) MONTHS
47 0

DURATION IN MONTHS
9

EFFECTIVE YEARS
46.33

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	2294.	4.2	1.48	67.3	3 1937	2.83
2	2415.	4.4	3.63	27.6	3 1940	2.12
3	5192.	9.6	5.77	17.3	2 1933	1.75
4	5434.	10.0	7.91	12.6	2 1935	1.50
5	5675.	10.4	10.05	10.0	2 1941	1.30
6	7003.	12.9	12.19	8.2	2 1931	1.14
7	7366.	13.6	14.33	7.0	2 1934	1.01
8	7788.	14.3	16.47	6.1	2 1932	.89
9	7788.	14.3	18.61	5.4	2 1938	.78
10	7969.	14.7	20.75	4.8	3 1942	.69
11	8633.	15.9	22.89	4.4	3 1962	.60
12	8754.	16.1	25.03	4.0	2 1936	.52
13	9237.	17.0	27.17	3.7	2 1939	.45
14	9599.	17.7	29.31	3.4	3 1949	.38
15	10988.	20.2	31.45	3.2	3 1951	.31
16	13524.	24.9	33.59	3.0	3 1955	.25
17	13584.	25.0	35.73	2.8	3 1965	.19
18	15335.	28.2	37.87	2.6	3 1971	.13
19	15637.	28.8	40.01	2.5	3 1948	.07
20	16120.	29.7	42.15	2.4	2 1957	.02
21	17689.	32.6	44.29	2.3	3 1968	-.03
22	17870.	32.9	46.43	2.2	4 1944	-.08
23	18233.	33.6	48.57	2.1	2 1950	-.13
24	19199.	35.3	50.71	2.0	3 1969	-.18

(continued)

YEARS (RECORD) MONTHS   DURATION IN MONTHS
47   0   12

EFFECTIVE YEARS
46.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	14731.	20.3	1.49	67.0	3 1932	2.82
2	17569.	24.3	3.64	27.4	4 1937	2.12
3	17931.	24.8	5.80	17.3	1 1935	1.75
4	19319.	26.7	7.95	12.6	4 1940	1.49
5	19802.	27.3	10.10	9.9	4 1942	1.30
6	20225.	27.9	12.25	8.2	9 1930	1.14
7	20949.	28.9	14.40	6.9	4 1933	1.00
8	20949.	28.9	16.56	6.0	3 1936	.88
9	23606.	32.6	18.71	5.3	4 1938	.79
10	31334.	43.3	20.86	4.8	6 1949	.68
11	31877.	44.0	23.01	4.3	8 1973	.60
12	34473.	47.6	25.16	4.0	4 1941	.52
13	36526.	50.4	27.32	3.7	3 1962	.44
14	39363.	54.3	29.47	3.4	6 1971	.37
15	41718.	57.6	31.62	3.2	7 1968	.30
16	47151.	65.1	33.77	3.0	6 1955	.24
17	48359.	66.8	35.92	2.8	9 1976	.18
18	53490.	73.8	38.07	2.6	4 1939	.12
19	57052.	78.8	40.23	2.5	5 1957	.07
20	62124.	85.8	42.38	2.4	4 1970	.01
21	62546.	86.3	44.53	2.2	6 1944	-.04
22	62667.	86.5	46.68	2.1	6 1948	-.09
23	65625.	90.6	48.83	2.0	6 1946	-.14
24	75949.	104.8	50.99	2.0	3 1964	-.19

(continued)

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 24

EFFECTIVE YEARS
45.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	34896.	24.1	1.53	65.5	2 1933	2.81
2	41054.	28.3	3.72	26.8	5 1935	2.10
3	41174.	28.4	5.92	16.9	4 1938	1.73
4	48902.	33.8	8.12	12.3	3 1941	1.47
5	94001.	64.9	10.32	9.7	6 1949	1.28
6	99676.	68.8	12.52	8.0	3 1943	1.12
7	116218.	80.2	14.72	6.8	6 1971	.98
8	131492.	90.8	16.92	5.9	6 1955	.86
9	133243.	92.0	19.12	5.2	4 1962	.76
10	143024.	98.7	21.32	4.7	3 1974	.66
11	148819.	102.7	23.52	4.3	5 1958	.58
12	149544.	103.2	25.72	3.9	3 1969	.50
13	167052.	115.3	27.92	3.6	3 1947	.42
14	169346.	116.9	30.12	3.3	3 1965	.35
15	186251.	128.5	32.31	3.1	6 1952	.28
16	340021.	234.7	34.51	2.9	3 1967	.22
17	349439.	241.2	36.71	2.7	3 1945	.16
18	365136.	252.0	38.91	2.6	9 1976	.10

INDEPENDENT EVENTS EXHAUSTED

(continued)

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 48

EFFECTIVE YEARS
43.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	76191.	26.3	1.60	62.7	9 1934	2.77
2	111932.	38.6	3.90	25.7	5 1940	2.06
3	266003.	91.8	6.20	16.1	5 1944	1.69
4	287074.	99.1	8.50	11.8	3 1950	1.44
5	308204.	106.4	10.80	9.3	6 1971	1.24
6	324022.	111.8	13.10	7.6	3 1962	1.08
7	339779.	117.3	15.40	6.5	8 1957	.94
8	476222.	164.3	17.70	5.7	6 1975	.83
9	499707.	172.4	20.00	5.0	12 1966	.72

INDEPENDENT EVENTS EXHAUSTED

1

YEARS (RECORD) MONTHS DURATION IN MONTHS
47 0 96

EFFECTIVE YEARS
39.08

NUMBER	VOLUME AC-FT	RATE CFS	EXCEED FREQ	RECUR INT	ENDING DATE	GUMBEL K
1	190899.	32.9	1.76	56.9	4 1938	2.69
2	638807.	110.2	4.29	23.3	5 1946	1.99
3	697550.	120.4	6.82	14.7	3 1962	1.62
4	742769.	~~128.2~~	~~9.36~~	~~10.7~~	~~3 1975~~	1.36

INDEPENDENT EVENTS EXHAUSTED

1

[illegible]

South Branch Buffalo River at Sabin - Year 1980 Case

(Same results as in year 2030 case. See table in Results of Year 2030 Partial Duration Analyses.)

END

FILMED

9-85

DTIC